APPENDIX A:

PHS CONSULTING PROSPECTUS

PHS CONSULTING PROSPECTUS

(REGISTERED:FYNBOSLAND 323 CC 2005/081216/23)

PHS CONSULTING IS ENVIRONMENTAL, HERITAGE, LAND USE AND ECO-TOURISM PLANNERS AND PRACTITIONERS

We have been providing professional services to the private and public sector since 1999. These include the agricultural, industrial, mining, urban, rural development and conservation sectors. We cover the entire sphere of legislative procedures required for development authorisation and compliance.

OUR TEAM

PAUL SLABBERT (Managing Member)graduated from the Potchefstroom University in 1995 with an honours degree B Art EtScien. His passion for environmental, heritage & land-use planning with knowledge of associated management strategies enable him to facilitate with all role players and to implement workable policies. His experience in rural and urban conservation with the emphasis on environmental impact and management with focus on sustainable development enabled him to publish various publications. He has hands-on expertise in the heritage, conservation and recreation disciplines with the emphasis on creating economic and employment opportunities. With sufficient practical experience in terms of the criteria of the Interim

Certificate Board for Environmental Assessment Practitioners of South Africa (EAPSA) for registration, Paul was registered as an Environmental Assessment Practitioner. He is also a member of the International Association for Impact Assessment (IAIA) and accredited with the Association of Professional Heritage Practitioners - Western Cape (APHP).

Professional Registration & Membership:

- Registered Impact Practitioner - Environmental Assessment Practitioners Association of South Africa (EAPASA). Registration Number 2019/1036
- Professional Certified Member of the Association of Professional Heritage Practitioners (APHP)
- Professional Member of the International Association for Impact Assessment (IAIA)

Amanda Fritz-Whyte graduated from Nelson Mandela Metropolitan University in 1998 with a Bachelors of Science Honours Degree in Geology, after which she completed a Masters Degree of Science in Water Resource Management in 2006 through University of Pretoria. She has 19 years experience in environmental management in the mining, motor manufacturing and construction industries, with specific reference to impact assessment, pollution management, EMS, water use licensing and auditing.

Professional Registration & Membership:

- Registered with South African Council of Natural Scientific Professions (SACNASP nr:*118385*)
- Professional Member of the International Association for Impact Assessment SA (IAIAsa)
- Professional Fellow Member of Water Institute of South Africa (WISA)
- Registered Impact Practitioner - Environmental Assessment Practitioners Association of South Africa (EAPASA). Registration Number 2019/367

Nadine Duncanobtained a Bachelor of Science Honours Degree in Geography as well as a Bachelor of Science Degree in Landscape Architecture- both from the University of Pretoria. With 14years experience in Impact Assessments and environmental management and a passion for sustainable development, responsibilities included Project Management, conducting Environmental Impact Assessments (Scoping/EIA's & BA's), Environmental Management Programmes, Public Participation Process facilitation, Open Space Planning, compilation of Environmental Management Frameworks and legal reviews. She is proficient in Geographic Information System (GIS) software and has a good understanding of the laws and regulations relating to air quality, water, biodiversity, heritage, and waste management in South Africa.

SERVICES

PHS consults across Southern Africa, and also specialises in Angolan and Zambian Environmental Impact Assessments

Our services include:

- Scoping and Environmental Impact Assessment
- Basic Assessment
- Heritage Impact Assessment
- Visual Impact Assessment
- Environmental Management Plans and Programmes
- Environmental Control officer
- Adhoc Setback Line Applications
- Public Participation
- Water Use Licence Applications, General Authorisation registrations and borehole registrations
- Water Tribunal Appeals
- Waste Management
- Estuarine / Marine Consulting

- River Rehabilitation
- S24G Applications
- Maintenance Management Plans
- Eco Tourism Planning

Corporate Responsibility:

- For overview of social and community engagement visit www.africanvisionfoundation.co.za

Advanced Legislative Knowledge:

Providing specialist services and managing and driving projects related to the following legislation:

- National Environmental Management Act (Act No. 107 of 1998) and 2017 Regulations;
- Environmental Conservation Act (Act No. 73 of 1989);
- National Heritage Resources Act (Act No. 25 of 1999);
- Land Use Planning Ordinance (Ordinance 15 of 1985);
- National Environmental Management: Integrated Coastal Management Act (Act No. 24 of 2008);
- National Environmental Management: Waste Act (Act No. 59 of 2008);
- National Environmental Management: Air Quality Act (Act No. 39 of 2004);
- Mineral and Petroleum Resources Development Act (Act No. 28 of 2002);
- National Water Act (Act 36 of 1998) and Regulations;
- National Water Services Act (Act 108 of 1997).

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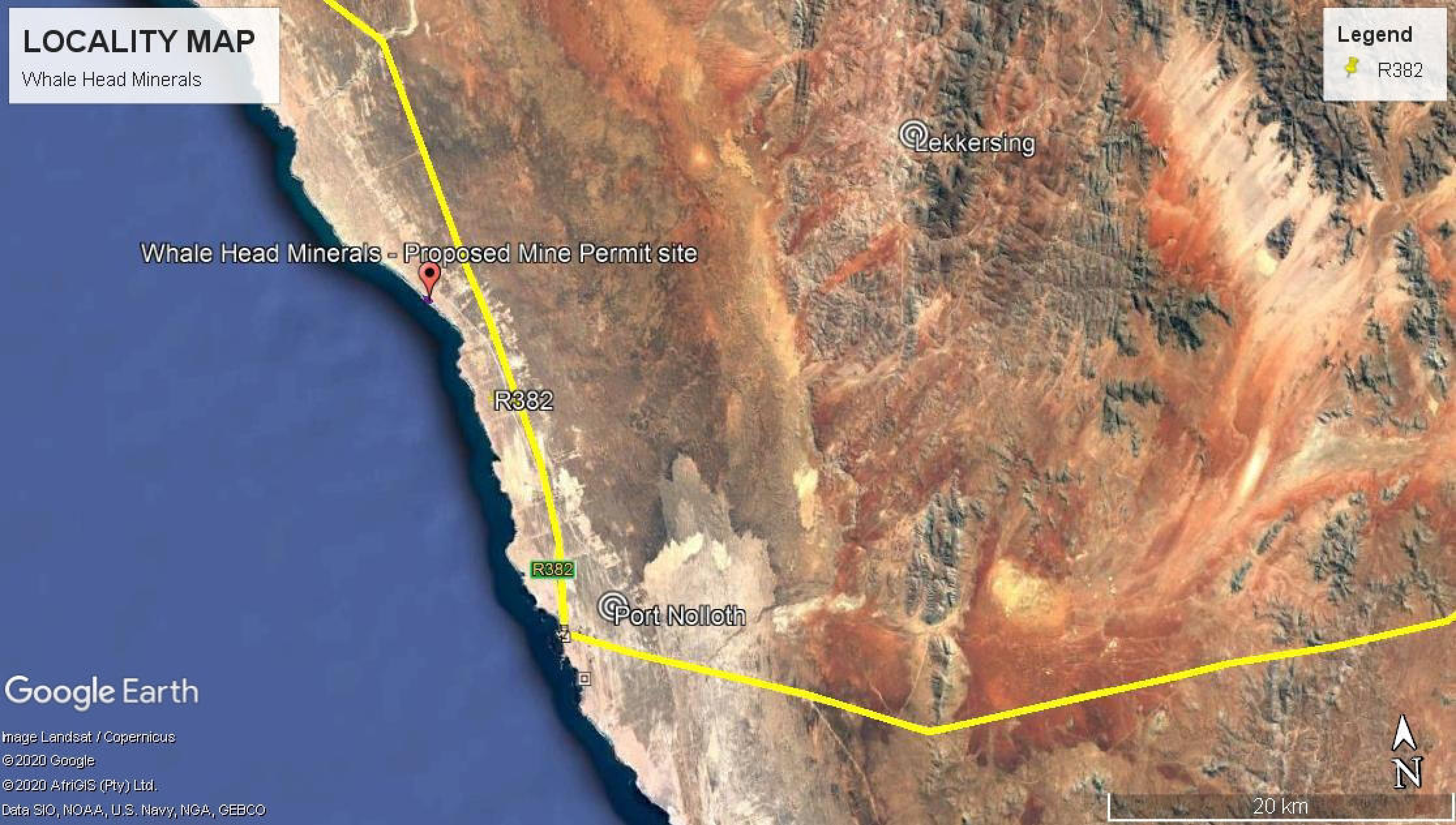
APPENDIX B:

LOCALITY MAP



LOCALITY MAP
Whale Head Minerals
Legend
R382
Lekkersing
Whale Head Minerals - Proposed Mine Permit site
R382
R382
Port Nolloth
Google Earth
Image Landsat / Copernicus
©2020 Google
©2020 AfriGIS (Pty) Ltd.
Data SIO, NOAA, U.S. Navy, NGA, GEBCO
N
20 km

APPENDIX C:

PROJECT FLOW DIAGRAM

Mining, Processing and rehabilitation plan
Walviskop, Port Nolloth, Northen Cape

Phase 1: Construction Phase - Plant Area and Infrastructure

- Road works
  - Acces road to be upgraded for distance of approximately 200m.
- Plant area (250m²)
  - The enite plant will have a plastic lining to contain all possible sea water drainage as well as a berm around it to contain spillage runoff.
  - Fuel storage area, including 68 000L diesel tank. Aboveground and bunded.
    Diesel generator.
    Bag storage area.
    Laboratory.
    Ablution block c/w sewage and waste disposal facilities.
    Office Block.
    Tea room.
    Wet Concentrator Plant (WCP)
    Process water dam.
    ROM stockpile gantry; feed bin and feed conveyor.
    Workshop and storage shed.
  - Main pipe spine consists of 3 lines: a water line transporting water from the process water dam to the mining operation, a tailings line returing WCP tailings to the beach and running adjacent to the water line, and a line transporting ROM slurry to the WCP from the mining operation.

Phase 2: Mining operation

- Beach material/slurry pumped at 260 tonnes per hour into main pipe spine along beach via excavator fitted with dredge pump.
- Sediment is pumped from mining area in surf zone and breaker zone to the beach via 250mm diameter pipe to the WCP.
- Mining operation will receive water via main pipe spine from a process water dam.
- The process water dam will be fed from a single fixed sea water intake located close to the WCP at 360m3/h.

Phase 3: Processing

- Wet Concentrator Plant (WCP) will receive sediment at a rate of approximately 260t/h. Some 5 - 10% of this will be retained as concentrate and the remaining 90 to 95% will be discarded as tailings.
- Processing waste deposits and evaporation ponds (salt)
- The plant will use sea water from the process water dam

Phase 4: Waste Disposal

- The non heavy mineral sand and oversize gravel fraction tailings from the WCP on is considered waste and gets returned to the surf zone by means of gravity flow and gets re-distributed and deposited by the wave action on the beach.

Phase 5: Stockpile and removal of heavy minerals

- Dispatch to Client

Phase 6: Rehabilitation and closure

- Rehabilitation of access roads
- Dismantling of processing plant
- Demolition of steel buildings & structures
- Demolition of reinforced concrete structures
- Demolition of housing and facilities
- Opencast rehabilitation including final voids and ramps
- Rehabilitation of overburden and spoils
- General surface rehab and grassing
- Water management
- 2-3 years of maintenance and aftercare

APPENDIX D-1:

MARINE ECOLOGY IMPACT ASSESSMENT

BASIC ASSESSMENT AS PART OF THE APPLICATION FOR A MINING PERMIT FOR HEAVY MINERALS, NORTHERN CAPE

Marine Ecology Assessment

Prepared for:

PHS Consulting

On behalf of:

Whale Head Minerals (Pty) Ltd

April 2020

BASIC ASSESSMENT AS PART OF THE APPLICATION FOR A MINING PERMIT FOR HEAVY MINERALS, NORTHERN CAPE

MARINE ECOLOGY ASSESSMENT

Prepared for

PHS Consulting

On behalf of:

Whale Head Minerals (Pty) Ltd

Prepared by

Andrea Pulfrich
Pisces Environmental Services (Pty) Ltd

April2020

PISCES Environmental Services (Pty) Ltd

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TABLE OF CONTENTS

ABBREVIATIONS and UNITS

BCC	Benguela Current Commission
BCLME	Benguela Current Large Marine Ecosystem
cm	centimetres
cm/s	centimetres per second
CBD	Convention of Biological Diversity
CITES	Convention on International Trade in Endangered Species
CMS	Centre for Marine Studies
CSIR	Council for Scientific and Industrial Research
DAFF	Department of Agriculture, Forestry and Fisheries
E	East
EBSA	Ecologically or Biologically Significant Area
ECOP	Environmental Code of Practice
EIA	Environmental Impact Assessment
EMPr	Environmental Management Programme
FAO	Food and Agricultural Organisation
g C/m^2/day	grams Carbon per square metre per day
GIS	Global Information System
ha	hectares
HABs	Harmful Algal Blooms
HWS	High Water Spring
IUCN	International Union for the Conservation of Nature
IWC	International Whaling Commission
km	kilometre
km^2	square kilometre
km/h	kilometres per hour
kts	knots
MPA	Marine Protected Area
m	metres
m^2	square metres
m^3	cubic metre
m^3/h	cubic metre per hour
mm	millimetres
mg/ℓ	milligrams per litre
N	north
NE	Northeast
NDP	Namibian Dolphin Project
NEMA	National Environmental Management Act
NNW	north-northwest
NW	north-west
PIM	Particulate Inorganic Matter
POM	Particulate Organic Matter
S	south
SACW	South Atlantic Central Water

SADCO	Southern Africa Data Centre for Oceanography
SANBI	South African National Biodiversity Institute
SLR	SLR Consulting (South Africa) (Pty) Ltd
SSW	South-southwest
SW	south-west
tons/h	tons per hour
tons/km^2	tons per square kilometre
TAC	Total Allowable Catch
TSPM	Total Suspended Particlate Matter
UNEP	United Nations Environmental Programme
VMEs	Vulnerable Marine Ecosystems
VOS	Voluntary Observing Ships
WCP	Wet Concentrator Plant
WSP	WSP Coastal and Port Engineers
wt%	percentage weight
µm	micrometre/micron
µM	microMol
°C	degrees Centigrade
%	percent
‰	parts per thousand
~	approximately
<	less than
>	greater than
± SD	plus/minus one Standard Deviation

GLOSSARY

Anti-cyclonic	An extensive system of winds spiralling outward anti-clockwise (in Southern Hemisphere) from a high-pressure centre.
Benthic	Referring to organisms living in or on the sediments of aquatic habitats (lakes, rivers, ponds, etc.).
Benthos	The sum total of organisms living in, or on, the sediments of aquatic habitats.
Benthic organisms	Organisms living in or on sediments of aquatic habitats.
Biodiversity	The variety of life forms, including the plants, animals and micro-organisms, the genes they contain and the ecosystems and ecological processes of which they are a part.
Biomass	The living weight of a plant or animal population, usually expressed on a unit area basis.
Biota	The sum total of the living organisms of any designated area.
Bivalve	A mollusk with a hinged double shell.
Community structure	All the types of taxa present in a community and their relative abundance.
Community	An assemblage of organisms characterized by a distinctive combination of species occupying a common environment and interacting with one another.
Cyclonic	An atmospheric system characterized by the rapid inward circulation of air masses about a low-pressure centre; circulating clockwise in the Southern Hemisphere
Dissolved oxygen (DO)	Oxygen dissolved in a liquid, the solubility depending upon temperature, partial pressure and salinity, expressed in milligrams/litre or millilitres/litre.
Epifauna	Organisms, which live at or on the sediment surface being either attached (sessile) or capable of movement.
Ecosystem	A community of plants, animals and organisms interacting with each other and with the non-living (physical and chemical) components of their environment.
Euphotic/photic zone	the zone in the ocean that extends from the surface down to a depth where light intensity falls to one percent of that at the surface; i.e. there is to sufficient sunlight for photosynthesis to occur.
Habitat	The place where a population (e.g. animal, plant, micro-organism) lives and its surroundings, both living and non-living.
Hypoxic	Deficiency in oxygen.
Infauna	Animals of any size living within the sediment. They move freely through interstitial spaces between sedimentary particles or they build burrows or tubes.
Intertidal	The area of seashore which is covered at high tide and uncovered at low tide.
Macrofauna	Animals >1 mm.
Macrophyte	A member of the macroscopic plant life of an area, especially of a body of water; large aquatic plant.
Meiofauna	Animals <1 mm.
Mariculture	Cultivation of marine plants and animals in natural and artificial environments.
Marine environment	Marine environment includes estuaries, coastal marine and near-shore zones, and open-ocean-deep-sea regions.
Pelagic	of or pertaining to the open seas or oceans; living at or near the surface of ocean.
Population	Population is defined as the total number of individuals of the species or taxon.

Recruitment	The replenishment or addition of individuals of an animal or plant population through reproduction, dispersion and migration.
Sediment	Unconsolidated mineral and organic particulate material that settles to the bottom of aquatic environment.
Species	A group of organisms that resemble each other to a greater degree than members of other groups and that form a reproductively isolated group that will not produce viable offspring if bred with members of another group.
Subtidal	The zone below the low-tide level, *i.e.* it is never exposed at low tide.
Supratidal	The zone above the high-tide level.
Surf-zone	Also referred to as the 'breaker zone' where water depths are less than half the wavelength of the incoming waves with the result that the orbital pattern of the waves collapses and breakers are formed.
Suspended material	Total mass of material suspended in a given volume of water, measured in mg/ℓ.
Suspended sediment	Unconsolidated mineral and organic particulate material that is suspended in a given volume of water, measured in mg/ℓ.
Taxon (Taxa)	Any group of organisms considered to be sufficiently distinct from other such groups to be treated as a separate unit (e.g. species, genera, families).
Turbidity	Measure of the light-scattering properties of a volume of water, usually measured in nephelometric turbidity units.
Vulnerable	A taxon is vulnerable when it is not Critically Endangered or Endangered but is facing a high risk of extinction in the wild in the medium-term future.

EXPERTISE AND DECLARATION OF INDEPENDENCE

This report was prepared by Dr Andrea Pulfrich of Pisces Environmental Services (Pty) Ltd. Andrea has a PhD in Fisheries Biology from the Institute for Marine Science at the Christian-Albrechts University, Kiel, Germany.

As Director of Pisces since 1998, Andrea has considerable experience in undertaking specialist environmental impact assessments, baseline and monitoring studies, and Environmental Management Programmes relating to marine diamond mining and dredging, hydrocarbon exploration and thermal/hypersaline effluents. She is a registered Environmental Assessment Practitioner and member of the South African Council for Natural Scientific Professions, South African Institute of Ecologists and Environmental Scientists, and International Association of Impact Assessment (South Africa).

This Specialist Report was compiled for PHS Consultingon behalf of Whale Head Minerals (Pty) Ltd for their use in preparing a Basic Assessment Report as part of the application for a mining permit for heavy minerals in the Alexkor mining licence area. I do hereby declare that Pisces Environmental Services (Pty)Ltd is financially and otherwise independent of the Applicant and PHS Consulting.

Andrea Pulfrich

Dr Andrea Pulfrich

1. GENERAL INTRODUCTION

PHS Consulting, has been appointedbyWhale Head Minerals (Pty) Ltd, to prepare an application for a mining permit to mine heavy minerals on a beach at Walviskop in the Alexkor Mining Licence Area (Mining Right 554MRC) north of Port Nolloth. The proposed mine site, situated ~2 km north of Jackals Pit, and ~15 km north of Port Nolloth, is an ~5 ha area located in the surf zone adjacent to the Concession Cliffs. Most of the site is located below the High Water Mark.

To meet the requirements of the Mineral and Petroleum Resources Development Act and the National Environmental Management Act (NEMA), a Basic Assessment is required in order to obtain environmental clearance for the proposed new activities. PHS Consulting are undertaking the required Basic Assessment process and in turn have approached Pisces Environmental Services (Pty) Ltd to provide the marine specialist inputs as part of the submission.

1.1. Scope of Work

The Terms of Reference for the marine ecology specialist study, are:

- Using a desktop approach, provide a marine ecological baseline of the intertidal and subtidal macrofaunal and floral communities in the project area.
- Based on information provided in the baseline description, identify and map key environmental constraints (e.g. sensitive marine receptors) that may impact the project design and/or site selection.
- Undertake an evaluation and assessment of the impacts of the proposed mining operations on the marine ecology in the project area. All identified marine and coastal impacts (direct, indirect and cumulative) would be summarised, categorised and ranked in appropriate impact assessment tables, to be incorporated in the overall Basic Assessment Report. The significance of the impacts would be rated according to the impact assessment methodology specified by the lead consultant and as required by the NEMA, and would include an assessment of the no-go alternative.
- Propose mitigatory measures and management actions to avoid impacts or reduce their severity.
- Recommend a defendable ecological monitoring programme that can quantitatively assess the impacts of the proposed mining operations on the marine environment and monitor the recovery of affected communities once mining ceases.

1.2. Approach to the Study

As specified in the Scope of Work, this marine specialist assessment has adopted a desktop approach. The assessment includes information on marine ecosystems and fisheries in the project area, and is based on a review and expert interpretation of all relevant, available local and international publications and information sources on the disturbances and risks associated

This specialist assessment only covers potential impacts from operations that affect the environment below the high water mark. Impacts associated with the location and construction of the Wet Concentrator Plant (WCP), construction of offices and facilities, roads and energy supply are covered in specialist studies compiled by other consultants. All identified marine impacts are summarised, categorised and ranked in appropriate impact assessment tables, to be incorporated in the overall Basic Assessment Report.

1.2.1 Assumptions, Limitations and Information Gaps

As determined by the terms of reference, this study has adopted a 'desktop' approach, supplemented by field information collected during a site visit to the Alexkor area in July 2017. Consequently, the description of the natural baseline environment in the study area is based on the descriptions provided in the Marine and Coastal Ecology Assesment compiled as part of the Amendment of Environmental Management Programmes for Alexkor's Mining Rights 554MRC, 10025MRC, 512MRC and 513MRC (Pulfrich 2017). Information had been updated where appropriate. The information for the identification of potential impacts of mining activities on the coastal and marine environment was drawn from various scientific publications, the Generic EMPr for Diamond Mining on the South African West Coast(Lane & Carter 1999) and the Benguela Current Large Marine Ecosystem (BCLME) Thematic Report (Clark *et al*.1999) and the assessment of cumulative effects of marine diamond mining activities on the BCLME Region (Penney *et al*. 2008) and information sourced from the Internet. The sources consulted are listed in the Reference chapter.

The study is based on the project description made available to the specialist at the time of the commencement of the study.

Information gaps relevant to this application include:

- information specific to the marine communities of intertidal rocky shores, and nearshore and deep-water reefs; and
- information specific to the marine communities of intertidal beaches in the project area in particular.

1.2.2 Impact Assessment Methodology

A brief tabulated summary of the impact assessment criteria appliedis provided below:

Rating	Definition of Rating
***Intensity** – establishes whether the magnitude of the impact is destructive or benign in relation to the sensitivity of the receiving environment*	
Zero to Very Low	Negligible change, disturbance or nuisance. The impact affects the environment in such a way that natural functions and processes are not affected.
Low	Minor (Slight) change, disturbance or nuisance. The impact on the environment is not detectable.
Medium	Moderate change, disturbance or discomfort. Where the affected environment is altered, but natural functions and processes continue, albeit in a modified way.
High	Prominent change, disturbance or degradation. Where natural functions or processes are altered to the extent that they will temporarily or permanently cease.

Rating	Definition of Rating
Duration *– the time frame over which the impact will be experienced*	
Short-term	<5 years
Medium-term	5 – 15 years
Long-term	>15 years, but where the impact will eventually cease either because of natural processes or by human intervention
Permanent	Where mitigation either by natural processes or by human intervention would not occur in such a way or in such time span that the impact can be considered transient
Extent *– defines the physical extent or spatial scale of the impact*	
Local	Extending only as far as the activity, limited to the site and its immediate surroundings
Regional	Impacts are confined to the region; e.g. coast, basin, etc
National	Impact is confined to the country as a whole, e.g. South Africa, Namibia, etc.
International	Impact extends beyond the national scale.
Reversibility - defines the potential for recovery to pre-impact conditions	
Irreversible	Where the impact is permanent
Partially Reversible	Where the impact can be partially reversed
Fully Reversible	Where the impact can be completely reversed
Probability *– the likelihood of the impact occurring*	
Improbable	Where the possibility of the impact to materialise is very low either because of design or historic experience, i.e. ≤ 30% chance of occurring.
Possible	Where there is a distinct possibility that the impact would occur, i.e. > 30 to ≤ 60% chance of occurring.
Probable	Where it is most likely that the impact would occur, i.e. > 60 to ≤ 80% chance of occurring.
Definite	Where the impact would occur regardless of any prevention measures, i.e. > 80% chance of occurring.
Degree of confidence in predictions *– in terms of basing the assessment on available information and specialist knowledge*	
Low	Less than 35 % sure of impact prediction.
Medium	Between 35 % and 70 % sure of impact prediction.
High	Greater than 70 % sure of impact prediction

Using the core criteria above, the consequence of the impact is determined:

***Consequence**– attempts to evaluatethe importance of a particular impact, and in doing so incorporates extent, duration and intensity*	
VERY HIGH	Impacts could be EITHER: of high intensity at a regional level and endure in the long term; OR of high intensity at a national level in the medium term; OR of medium intensity at a national level in the long term.
HIGH	Impacts could be EITHER: of high intensity at a regional level enduring in the medium term; OR of high intensity at a national level in the short term; OR of medium intensity at a national level in the medium term; OR of low intensity at a national level in the long term; OR of high intensity at a local level in the long term; OR of medium intensity at a regional level in the long term.
MEDIUM	Impacts could be EITHER: of high intensity at a local level and endure in the medium term; OR of medium intensity at a regional level in the medium term; OR of high intensity at a regional level in the short term; OR of medium intensity at a national level in the short term; OR of medium intensity at a local level in the long term; OR of low intensity at a national level in the medium term; OR of low intensity at a regional level in the long term.
LOW	Impacts could be EITHER of low intensity at a regional level, enduring in the medium term; OR of low intensity at a national level in the short term; OR of high intensity at a local level and endure in the short term; OR of medium intensity at a regional level in the short term; OR of low intensity at a local level in the long term; OR of medium intensity at a local level, enduring in the medium term.
VERY LOW	Impacts could be EITHER of low intensity at a local level and endure in the medium term; OR of low intensity at a regional level and endure in the short term; OR of low to medium intensity at a local level, enduring in the short term; OR Zero to very low intensity with any combination of extent and duration.
UNKNOWN	Where it is not possible to determine the significance of an impact.

The consequence rating is considered together with the probability of occurrence in order to determine the overall significance using the table below.

		PROBABILITY			
		IMPROBABLE	POSSIBLE	PROBABLE	DEFINITE
CONSEQUENCE	VERY LOW	INSIGNIFICANT	INSIGNIFICANT	VERY LOW	VERY LOW
	LOW	VERY LOW	VERY LOW	LOW	LOW
	MEDIUM	LOW	LOW	MEDIUM	MEDIUM
	HIGH	MEDIUM	MEDIUM	HIGH	HIGH
	VERY HIGH	HIGH	HIGH	VERY HIGH	VERY HIGH

Nature of the Impact *– describes whether the impact would have a negative, positive or zero effect on the affected environment*	
Positive	The impact benefits the environment
Negative	The impact results in a cost to the environment
Neutral	The impact has no effect

Type of impacts assessed:

Type of impacts assessed	
Direct (Primary)	Impacts that result from a direct interaction between a proposed project activity and the receiving environment.
Secondary	Impacts that follow on from the primary interactions between the project and its environment as a result of subsequent interactions within the environment (e.g. loss of part of a habitat affects the viability of a species population over a wider area).
Indirect	Impacts that are not a direct result of a proposed project, often produced away from or as a result of a complex impact pathway.
Cumulative	*Additive*: impacts that may result from the combined or incremental effects of future activities (i.e. those developments currently in planning and not included as part of the baseline); and
	In-combination: impacts where individual project-related impacts are likely to affect the same environmental features. For example, a sensitive receptor being affected by both noise and drill cutting during drilling operations could potentially experience a combined effect greater than the individual impacts in isolation.

The relationship between the significance ratings after mitigation and decision-making can be broadly defined as follows:

Significance of residual impacts after Mitigation *- considering changes in intensity, extent and duration after mitigation and assuming effective implementation of mitigation measures*	
Very Low; Low	Activity could be authorised with little risk of environmental degradation.
Medium	Activity could be authorised with conditions and inspections.
High	Activity could be authorised but with strict conditions and high levels of compliance and enforcement.
Very High	Potential fatal flaw

2. DESCRIPTION OF THE PROPOSED PROJECT

2.1. Introduction

The Mining Works Programme provides details on the location and extent of known and probable mineral sands at a small pocket beach in the Alexkor Mining Licence Area. It is estimated that some 622 700tons of ore would be mined from the beach over a 5-year period, producing high grade heavy minerals concentrates including garnet, ilmenite, monazite, zircon and rutile.The possibility of unrealized potential in the resource through the replenishment of the resource by resupply from beyond the surf zone and by the longshore drift may extend the expected life-of-mine.

2.2. Previous Mining History

Diamonds have been actively mined in the Alexkor Licence Areas since 1928. Historical mining areas associated with the marine Mining Rights and future targets outlined in Alexkor's 2017 Mine Plan are indicated inFigure 2-1. From this it is evident that the Walviskop area has been actively mined on an ongoing basis since 2004. During the amendment process of the Alexkor Environmental Management Programmes for Mining Rights 554MRC, 10025MRC, 512MRC and 513MRC (SLR 2018), the Walviskop pocket beach, was identified as a future mining target and was included as part of Alexkors Mining Works Plan.

Figure 2-1: Historical and future marine mining locations (adapted from SLR 2018).

The Walviskop target falls within Alexkor's Mining Right 554MRC. Mining operations at Walviskop have focused on the surf zone using primarily shore-based diver-assisted dredge pumps (walpompe) and to a lesser extent vessel-based diver-assisted dredge pumping in slightly deeper water. Beach mining using heavy earth-moving equipment has taken place during at least two mining campaigns since 2013 (Johan Hattingh, Geological & GIS Consulting, pers. comm. March 2020).

2.3. Proposed Mining Approach

The beach at Walviskop will be mined using an excavator fitted with an hydraulically driven submersible dredge pump fitted onto the excavator's boom (Figure 2-2). The submersible dredge pump will be equipped with a high-pressure water jet-ring system capable of delivering 100m^3 of water at a pressure of 6 – 7 bar into the pump suction area. The jet system liquifies the beach sands around the suction headinto a slurry that is subsequently pumped from the mining area at a rate of approximately 260tons/h*via* a 25mm diameter pipe spine installed along the length of the beach and leading to a wet concentrator plant (WCP) located on the rocky headland to the north of the target area. Two excavators will be operational at any one time.

Figure 2-2: Dredging unit mounted on an excavator (Source: Hannesko).

The mining operation will thus comprise a land-based approach advancing from the toe of the cliff, across the beach into the surf zone. Mobility of equipment on the beach is essential so that equipment can be rapidly and efficently retracted at the onset of unfavourable sea conditions.

The mining target area will be divided into 100 x 100m blocks,with mining progressing from south to north along the beach, commencing with the blocks closest to the low water mark (Figure 2-3). Mining will only take place beyond 10 m from the toe of the cliff towards the sea.Mining will be active for 16 hours per day for 250 days per year, the remaining time lost mainly due to inclement sea conditions.

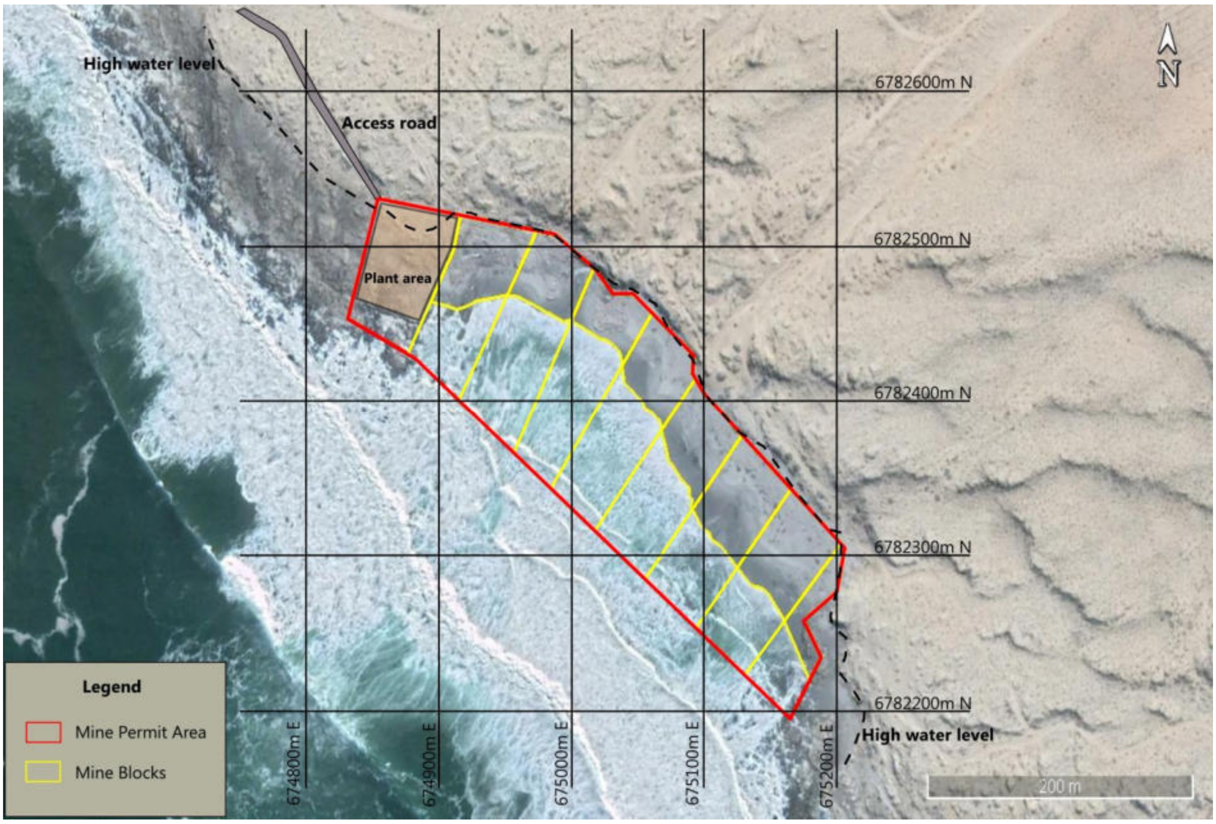


Figure 2-3: Mining Permit Area indicating locations of the mining blocks and the processing plant (Source: Mine Works Programme).

The main pipe spine that will run along the length of the beach, 10m from the base of the cliff,will consist of three separate lines, namely 1) a water line transporting water from the process water dam in the plant area to the excavators on the beach,2)a line transporting the Run-of-Mine slurry from the excavators to the WCP, and 3) a line returning tailings from the WCP back to the beach. Tie-in points will be positioned every 50 m along the beach to facilitate the relatively rapidmining advance rate from south to north along the beach. The excavators will be connected to the booster pumps by flexible hose that will allow them to move as the mining operation advances.The movement of piping on the beach will require the use of heavy machinery, both during initial installation or removal off the beach should sea conditions require.

The process water for the liquifaction of the beach sands will be sourced from a single beach well buried in the northern portion of the beach near the WCP. The fixed sea water intake will supply water to the process water dam in the plant area at a nominal rate of 360 m^3/h. The supply of water to the excavators and the Run-of-Mine slurry is controlled to maintain a density of 30% solids by mass thereby maintaining the low flow conditions of the slurry. The process water dam will also receive run-off water from the Run-of-Mine stockpiles, and return water from the WCP. Excess water from the dam, together with silts removed from the dam's sand trap, will return to the beach *via* an overflow.

The slurry from the excavators will be fed directly from the pipeline through a 2 mm trommel screen into the WCP. Oversize (>2 mm) from the trommel screen will be stockpiled in the plant area, while the undersize (<2 mm) will be discharged into a densifying cyclone and further into various spiral banks in the gravity concentration area of the WCP. Of the material processed, some 40-50% will be retained as heavy minerals concentrate and the remaining 50-60% will be discarded as tailings. The tailings (including the >2 mm oversize from the trommel screen) will be discharged into a steel bin (sump) prior to being returned to the beach. Two alternatives are being considered, namely to pump the tailings back to the mined-out areas in the surf zone *via* a 500 mm diameter flexi-hose or to return the tailings to the northern portion of the beach below the plant area by gravity feed. For the first option, the end of the discharge pipe would be constantly moved in parallel with the excavator to ensure backfilling of the mine-out area. The coarser tailings and oversize would settle rapidly into the excavated depressions upon discharge while the finer fractions would remain in suspension for longer.Care will be taken to avoid the discharge of tailings onto rocky shore habitats. Discharging tailings onto the northern portion of the beach via gravity feed would fascilitate the natural redistribution of the tailings across the length of the beach by the southward-flowing counter current eddy responsible for the typical sediment accumulation on the beach.

Provision will also been made in the plant area for an emergency five-day Run-of-Mine stockpile. The stockpile would be created by feeding excess slurrythrough stacker cyclones, which will dewater the material. Water run-off will be channelled into the process water dam and once dewatered, the material will be placed on an adjacent stockpile by a front-end loader. This stockpile will provide material to the plant when the excavators cannot be operational on the beach due to routine maintenance, refuelling, unexpected breakdowns or adverse sea conditions.

3. DESCRIPTION OF THE BASELINE MARINE ENVIRONMENT

The descriptions of the physical and biological environments along the South African West Coast focus primarily on the broader study area between the Orange River mouth and Hondeklipbaai. The purpose of this environmental description is to provide the marine baseline environmental context within which the proposed heavy mineral mining would take place. The summaries presented below are primarily based on information gleaned from Lane & Carter (1999) and Penney *et al.* (2007), and supplemented by updated references where appropriate. These were presented in the marine ecology specialist report as part of the Alexkor EMPr Amendment (Pulfrich 2018) and have been updated here as necessary.

3.1. Geophysical Characteristics

3.1.1 Bathymetry and Coastal Topography

The continental shelf along the West Coast is generally wide and deep, although large variations in both depth and width occur. The shelf maintains a general NNW trend, widening north of Cape Columbine and reaching its widest off the Orange River (180 km).Between Cape Columbine and the Orange River, there is usually a double shelf break, with the distinct inner and outer slopes, separated by a gently sloping ledge. The immediate nearshore area consists mainly of a narrow (about 8 km wide) rugged rocky zone, sloping steeply seawards to a depth of around 80 m. The middle and outer shelf typically lacks relief, sloping gently seawards before reaching the shelf break at a depth of ~300 m.

Walviskop is a south-west facing pocket beach approximately 13 km south of the Holgat River mouth. It is typical of the short beaches within small embayments that characterise the rugged quartzite and sandstone coastline south of the Orange River mouth. Although detailed bathymetry of the nearshore regions of the project area are not available, 1-m bathymetry contours from Concession 1a suggest that the depth just beyond the surf zone in small bays similar to that at Walviskop is in the order of -5 m. The seabed slope of the bay averages 0.01. A feature of the bay is a prominent sand-influenced rocky outcrop in the mid- to lowshore on the southern portion of the ~400 m long beach. The beach, which is the northern-most of a series of three small beaches, is bounded to the north and south by rugged rocky coastline and rocky cliffs. The two beaches to the south of the target area have sands in the upper shore only, with the mid- and lowshore reaches being characterised by rocky shores. Some 2 km south of the target beach, the coastline becomes cliffed. These coastal cliffs that characterise the shoreline of the Cliffs and Langpan concessions have been identified as having high natural sensitivity (SLR 2018)(Figure 3-2).

Figure 3-1: GoogleEarth image indicating the position of the target area (red polygon) in relation to nearby pocket beaches, cliffed coastline and historic mining damage.

3.1.2 Coastal Geology and Seabed Geomorphology

The description of the coastal geology in the project area is drawn from Alexkor's 2004 EMPr (CSIR1994), the 2008 Revised EMPr (Site Plan Consulting 2008)and the Whale Head Minerals' Mine Works Programme.

The Alexkor mine is underlain by Late Precambrian basement rocks of the Gariep Complex comprising the Holgat, Oranjemund and Grootderm Suites, and the Stinkfontein Formation.A few small scattered outcrops of Cambrian granite of the Swartbank Pluton occur in the east of the licence area. The Boegoeberg Twins, which consist of remnant Gariep metamorphic rocks, make the Alexkor coastline the only inselberg coast in southern Africa.

The project area at Walvislop falls within the Holgat Suite, which extends from Cape Voltas southwards to just north of Cliff Point. It consists of schist, gneiss, greywacke, arenite, limestone, quartzite and arkose.

Early Pliocene to Late Quaternary hiatuses in sea level regression resulted in the erosion of four wave cut platforms ranging from 95 m above current sea level to mean sea level.The various terraces are generally separated by areas of bedrock covered by littoral sands. Marine sediments have been left behind on the terraces either as beach deposits or lag gravels, consisting of basal diamondiferous gravels intermittently overlain by marine sands, gravels and shells, which may occasionally be indurated to sandstone, and conglomerate, locally referred to as "Vaalbank". These marine sediments, vary in thickness from a few centimetres to more than 10 m.The entire sequence including the Lower Terrace deposits and adjacent bedrock are covered by coastal dune sands along the coastal strip. These dune sands and the underlying terrigenous sands are of Pleistocene age and belong to the Bredasdorp Formation.

The coast is predominantly rocky with 42% being rocky headlands and 32% wave-cut rocky platforms. Approximately 26% of the Alexkor coastline is classified as sandy beaches. These beaches are usually backed by a relatively narrow hummock dune zone.

At Walviskop,the nearshore sediments comprise a marine gravel layer resting on a gently seaward sloping bedrock platform. The gravel in turn is overlain by a medium to coarse-grained layer of beach sand, which hosts the mineralised heavy minerals.The bed rock basement on the platform is characterised by an uneven surface with gullies, potholes and large boulders (>400 mm) in places. The gravel layer, which varies in thickness between 1.0 and 1.5m, rests on the bedrock. The gravel consists of gravel clasts, which range in size from >100mm (8%) to 100 – 2mm (92%) and comprise almost entirely of quartzite and vein quartz,as well as shell fragments and subordinate sand-size material.

The overlaying beach sand layer is on average 3 - 5 m thick, comprising a ~50/50% mix of coarse- to medium-grained quartz sand, broken shell material and heavy minerals. The heavy minerals occur as a compact well-packed layer prone to continuous relocation by bottom currents, particularly during storm events.As part of a natural sedimentary cycle, the coastline is subject to gradual accumulation of sand deposits during summer, and subsequent beach erosion during winter. Superimposed on this seasonal pattern are bi-weekly, daily, and storm-associated sand movements, when temporary reversal in the sediment transport direction occurs in response to short-term changes in wave conditions. Erosion of sand from the beach during storm events can result in a severe thinning of the sand layer, or the total absence of sands.

On the southern African West coast, mineralization of heavy minerals develop in the sandy beach deposits of well-developed south facing log spiral bays. The heavy mineral suites in the project area are diverse, consisting of various proportions of ilmenite and its related alteration products, hematite, magnetite as well as rutile, zircon, garnet, amphibole, pyroxene, epidote, aluminosilicates, titanite, monazite, staurolite, collophane and glauconite. The economically viable minerals, ilmenite, rutile, garnet, monazite and zircon constitute a very large portion of the total heavy mineral suite, often an order of magnitude greater than the gangue. Generally, the total heavy mineral suite in the area is dominated by ilmenite (50 – 73 wt%), with garnet (6 –12 wt%), zircon (5 -7 wt%), monazite (2 – 3 wt%), and rutile (1 wt%) constituting the rest of the economic fraction.

3.2. Biophysical Characteristics

3.2.1 Wind Patterns

Winds are one of the main physical drivers of the nearshore Benguela region, both on an oceanic scale, generating the heavy and consistent south-westerly swells that impact this coast, and locally, contributing to the northward-flowing longshore currents, and being the prime mover of sediments in the terrestrial environment. Physical processes are characterised by the average seasonal wind patterns, and substantial episodic changes in these wind patterns have strong effects on the entire Benguela region.

The prevailing winds in the Benguela region are controlled by the perennial South Atlantic subtropical anticyclone, the eastward moving mid-latitude cyclones south of southern Africa, and the seasonal atmospheric pressure field over the subcontinent. The south Atlantic anticyclone undergoes seasonal variations, being strongest in the austral summer, when it also attains its southernmost extension, lying south west and south of the subcontinent. In winter, the south Atlantic anticyclone weakens and migrates north-westwards.

These seasonal changes result in substantial differences between the typical summer and winter wind patterns in the region, as the southern hemisphere anti-cyclonic high-pressures system, and the associated series of cold fronts, moves northwards in winter, and southwards in summer. The strongest winds occur in summer, during which winds blow 99% of the time Virtually all winds in summer come from the southeast to south-west (Figure 3-2; supplied by CSIR), strongly dominated by southerlies which occur over 40% of the time, averaging 20-30 kts and reaching speeds in excess of 100 km/h (60 kts). South-easterlies are almost as common, blowing about one-third of the time, and also averaging 20 - 30 kts. The combination of these southerly/south-easterly winds drives the offshore movements of surface water, and the resultant strong upwelling of nutrient-rich bottom waters, which characterise this region.

Winter remains dominated by southerly to south-easterly winds, but the closer proximity of the winter cold-front systems results in a significant south-westerly to north-westerly component (Figure 3-2). This ‘reversal’ from the summer condition results in cessation of upwelling, movement of warmer mid-Atlantic water shorewards and breakdown of the strong thermoclines which develop in summer. There are more calms in winter, occurring about 3% of the time, and wind speeds generally do not reach the maximum speeds of summer. However, the westerlies winds blow in synchrony with the prevailing south-westerly swell direction, resulting in heavier swell conditions in winter.

3.2.2 Large-Scale Circulation and Coastal Currents

The West Coast is strongly influenced by the Benguela Current, with current velocities in continental shelf areas ranging between 10–30 cm/s (Boyd & Oberholster 1994). On its western side, flow is more transient and characterised by large eddies shed from the retroflection of the Agulhas Current. The Benguela current widens northwards to 750 km, with flows being predominantly wind-forced, barotropic and fluctuating between poleward and equatorward flow (Shillington *et al*. 1990; Nelson &Hutchings 1983).Fluctuation periods of these flows are 3 - 10 days, although the long-term mean current residual is in an approximate northwest (alongshore) direction. Near-bottom shelf flow is mainly poleward (Nelson 1989) with low velocities of typically 5 cm/s.

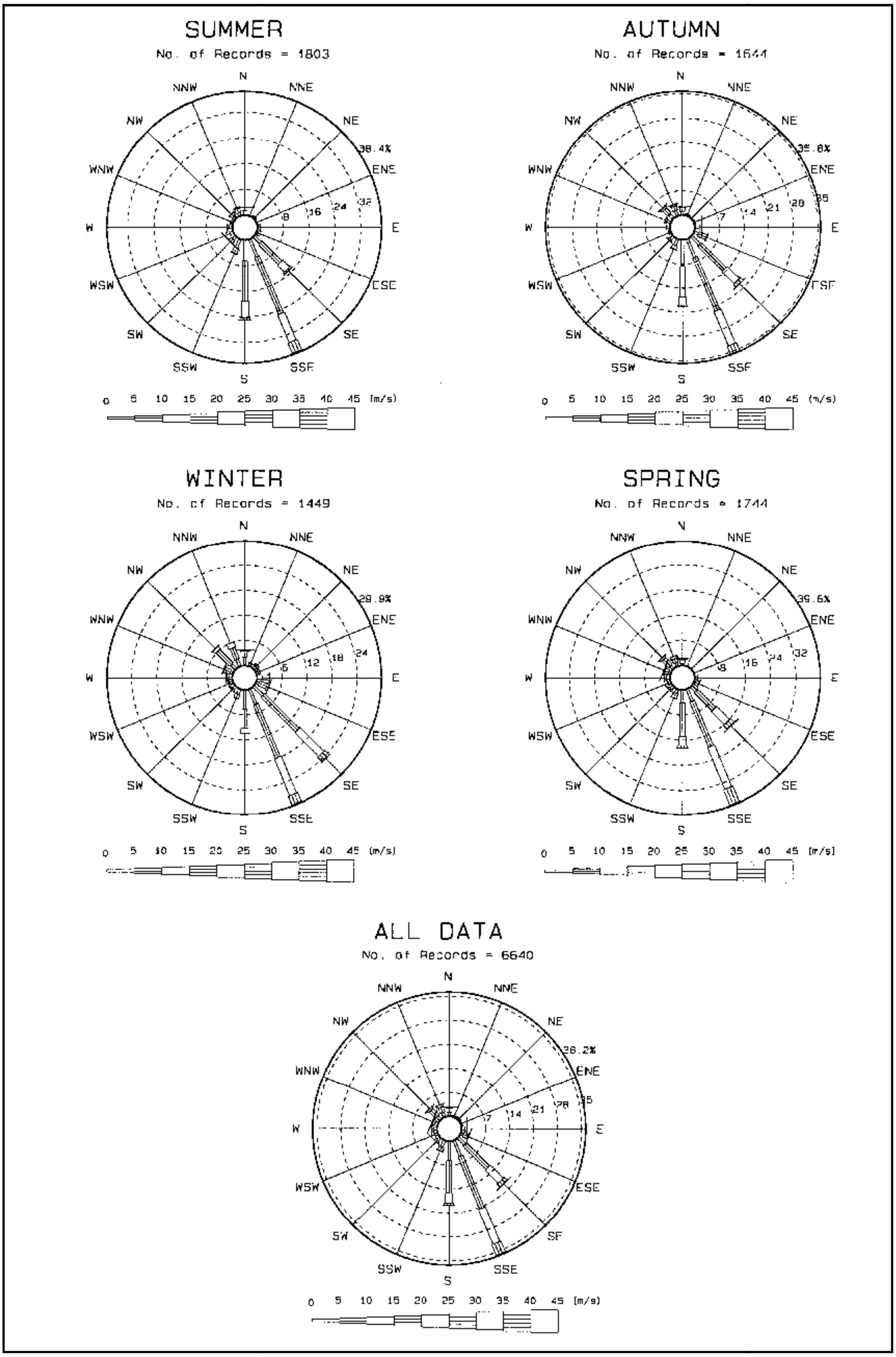


Figure 3-2: VOS Wind Speed vs Wind Direction data for the offshore area 28°-29°S; 15°-16°E (Oranjemund) (Source: Voluntary Observing Ship (VOS) data from the Southern Africa Data Centre for Oceanography (SADCO)).

The major feature of the Benguela Current Coastal is upwelling and the consequent high nutrient supply to surface waters leads to high biological production and large fish stocks. The prevailing longshore, equatorward winds move nearshore surface water northwards and offshore. To balance the displaced water, cold, deeper water wells up inshore. Although the rate and intensity of upwelling fluctuates with seasonal variations in wind patterns, the most intense upwelling tends to occur where the shelf is narrowest and the wind strongest. There are three upwelling centres in the southern Benguela, namely the Namaqua (30°S), Cape Columbine (33°S) and Cape Point (34°S) upwelling cells (Taunton-Clark 1985) (Figure 3-3; bottom left). The project area falls into the Namaqua cell. Upwelling in these cells is seasonal, with maximum upwelling occurring between September and March. An example of one such strong upwelling event in December 1996, followed by relaxation of upwelling and intrusion of warm Agulhas waters from the south, is shown in the satellite images in Figure 3-3.

Where the Agulhas Current passes the southern tip of the Agulhas Bank(Agulhas Retroflection area), it may shed a filament of warm surface water that moves north-westward along the shelf edge towards Cape Point, and Agulhas Rings, which similarly move north-westwards into the South Atlantic Ocean. These rings may extend to the seafloor and west of Cape Town may split, disperse or join with other rings (Figure 3-3). During the process of ring formation, intrusions of cold subantractic water moves into the South Atlantic. The contrast in warm (nutrient-poor) and cold (nutrient-rich) water is thought to be reflected in the presence of cetaceans and large migratory pelgic fish species (Best 2007).

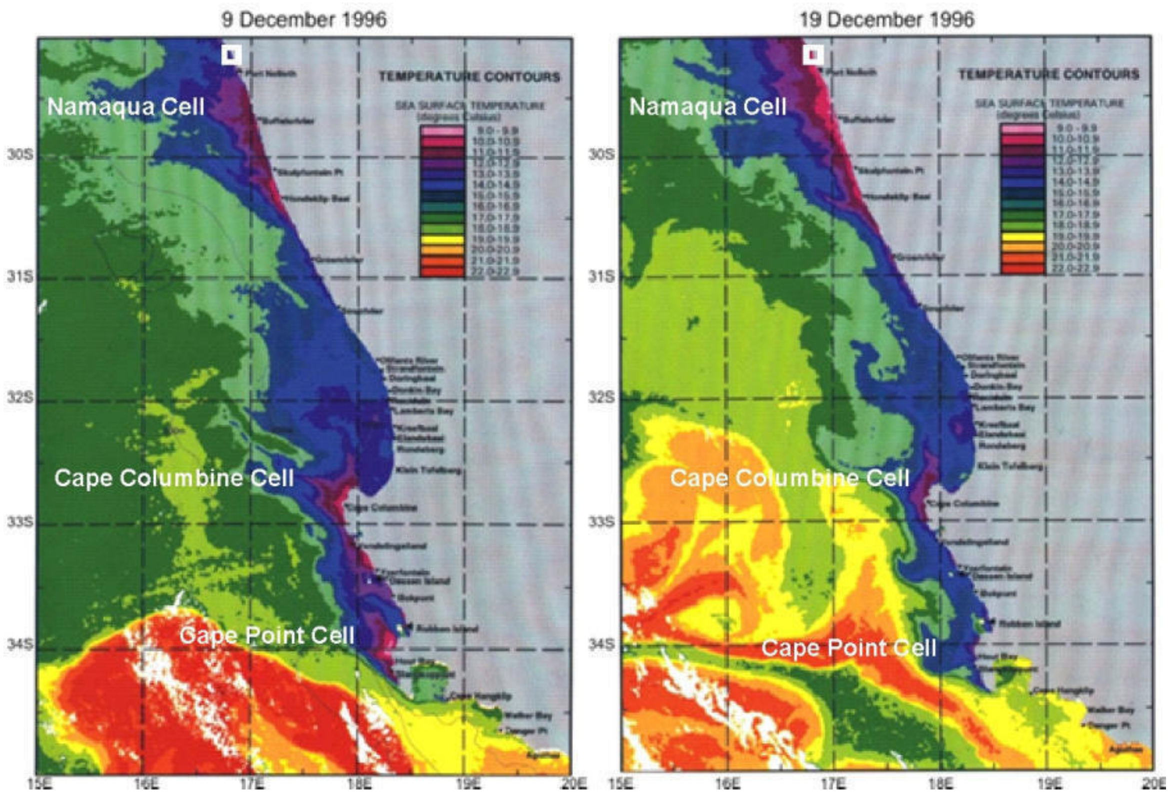


Figure 3-3: Satellite sea-surface temperature images showing upwelling intensity in the three upwelling cells along the South African west coast on two days in December 1996 (from Lane & Carter 1999). The location of the proposed project area (white square) is indicted.

3.2.3 Waves and Tides

Most of the west coast of southern Africa is classified as exposed, experiencing strong wave action, rating between 13-17 on the 20 point exposure scale (McLachlan 1980). Much of the coastline is therefore impacted by heavy south-westerly swells generated in the roaring forties, as well as significant sea waves generated locally by the prevailing southerly winds.The peak wave energy periods fall in the range 9.7 – 15.5 seconds.

The wave regime along the southern African west coast shows only moderate seasonal variation in direction, with virtually all swells throughout the year coming from the SW - S direction (Figure 3-4). Winter swellsare strongly dominated by those from the SW - SSW, which occur almost 80% of the time, and typically exceed 2 m in height, averaging about 3 m, and often attaining over 5 m. With wind speeds capable of reaching 100 km/h during heavy winter south-westerly storms, winter swell heights can exceed 10 m.Typical seasonal swell-height rose-plots, compiled from Voluntary Observing Ship (VOS) dataoff Oranjemund, are shown in Figure 3-4 (supplied by CSIR).

Summer swells tend to be smaller on average (~2 m), with a more pronounced southerly component. These southerly swells tend to be wind-induced, with shorter wave periods (~8 seconds), and are generally steeper than swell waves (CSIR 1996).These wind-induced southerly waves are relatively local and, although less powerful, tend to work together with the strong southerly winds of summer to cause the northward-flowing nearshore surface currents, and result in substantial nearshore sediment mobilisation, and northwards transport, by the combined action of currents, wind and waves.

In common with the rest of the southern African coast, tides are semi-diurnal, with a total range of some 1.5 m at spring tide, but only 0.6 m during neap tide periods.

3.2.4 Water

South Atlantic Central Water (SACW) comprises the bulk of the seawater in the project area, either in its pure form in the deeper regions, or mixed with previously upwelled water of the same origin on the continental shelf (Nelson & Hutchings 1983). Salinities range between 34.5 ‰ and 35.5‰ (Shannon 1985).

Seawater temperatures on the continental shelf typically vary between 6°C and 16°C. Well-developed thermal fronts exist, demarcating the seaward boundary of the upwelled water. Upwelling filaments are characteristic of these offshore thermal fronts, occurring as surface streamers of cold water, typically 50 km wide and extending beyond the normal offshore extent of the upwelling cell. Such fronts typically have a lifespan of a few days to a few weeks, with the filamentous mixing area extending up to 625 km offshore.

The continental shelf waters of the Benguela system are characterised by low oxygen concentrations, especially on the bottom. SACW itself has depressed oxygen concentrations (~80% saturation value), but lower oxygen concentrations (<40% saturation) frequently occur (Bailey *et al.* 1985; Chapman & Shannon 1985).

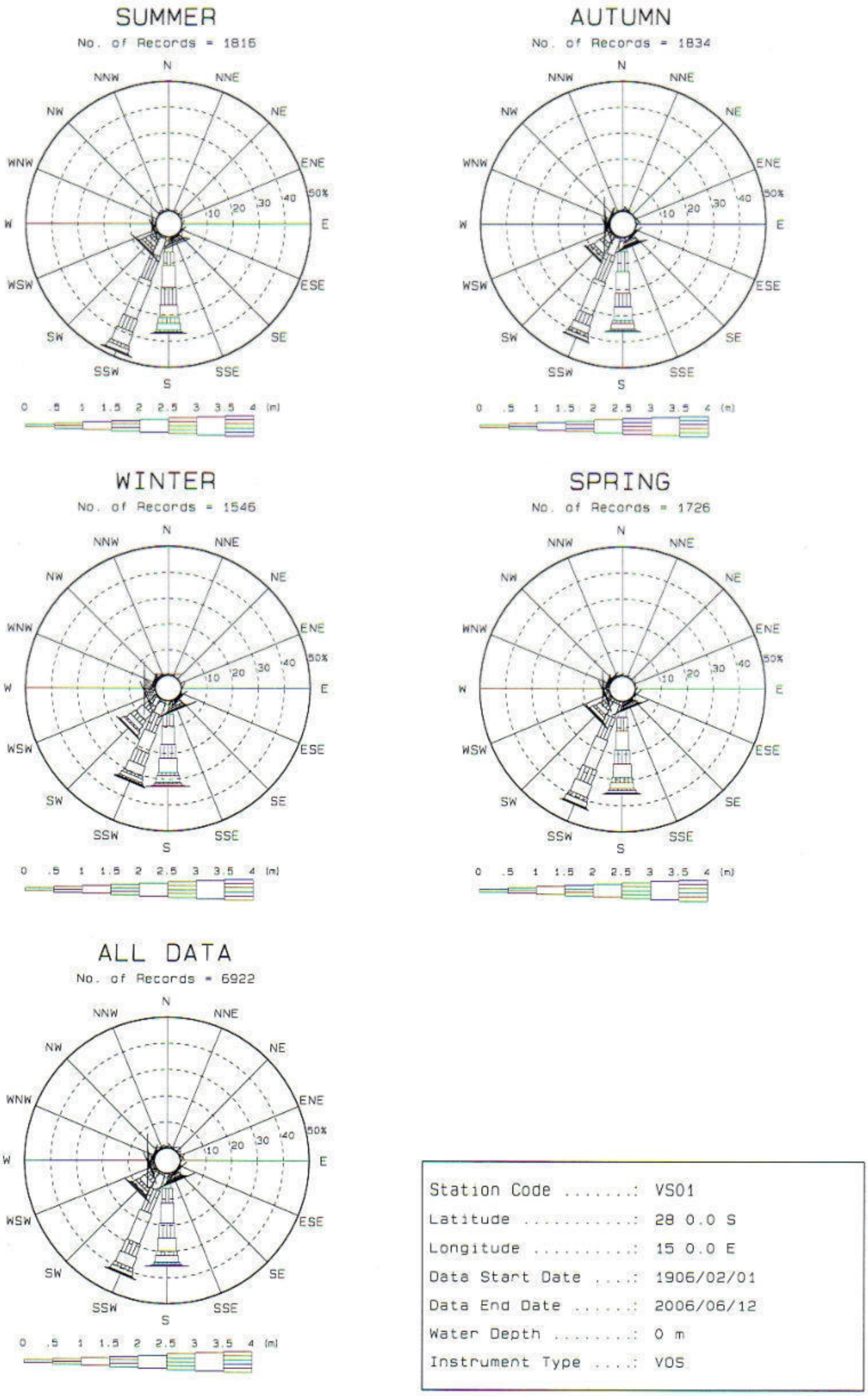


Figure 3-4: VOS Wave Height vs Wave Direction data for the offshore area (28°-29°S; 15°-16°E recorded during the period 1 February 1906 and 12 June 2006)) (Source: Voluntary Observing Ship (VOS) data from the Southern African Data Centre for Oceanography (SADCO)).

Nutrient concentrations of upwelled water attain 20 µm nitrate-nitrogen, 1.5 µM phosphate and 15-20 µM silicate, indicating nutrient enrichment (Chapman & Shannon 1985). This is mediated by nutrient regeneration from biogenic material in the sediments (Bailey *et al.* 1985). Modification of these peak concentrations depends upon phytoplankton uptake which varies according to phytoplankton biomass and production rate. The range of nutrient concentrations can thus be large but, in general, concentrations are high.

3.2.5 Upwelling & Plankton Production

The cold, upwelled water is rich in inorganic nutrients, the major contributors being various forms of nitrates, phosphates and silicates (Chapman & Shannon 1985). During upwelling the comparatively nutrient-poor surface waters are displaced by enriched deep water, supporting substantial seasonal primary phytoplankton production. This, in turn, serves as the basis for a rich food chain up through zooplankton, pelagic baitfish (anchovy, pilchard, round-herring and others), to predatory fish (hake and snoek), mammals (primarily seals and dolphins) and seabirds (jackass penguins, cormorants, pelicans, terns and others). High phytoplankton productivity in the upper layers again depletes the nutrients in these surface waters. This results in a wind-related cycle of plankton production, mortality, sinking of plankton detritus and eventual nutrient re-enrichment occurring below the thermocline as the phytoplankton decays.

3.2.6 Organic Inputs

The Benguela upwelling region is an area of particularly high natural productivity, with extremely high seasonal production of phytoplankton and zooplankton. These plankton blooms in turn serve as the basis for a rich food chain up through pelagic baitfish (anchovy, pilchard, round-herring and others), to predatory fish (snoek), mammals (primarily seals and dolphins) and seabirds (jackass penguins, cormorants, pelicans, terns and others). All of these species are subject to natural mortality, and a proportion of the annual production of all these trophic levels, particularly the plankton communities, die naturally and sink to the seabed.

Balanced multispecies ecosystem models have estimated that during the 1990s the Benguela region supported biomasses of 76.9 tons/km^2 of phytoplankton and 31.5 tons/km^2 of zooplankton alone (Shannon *et al.* 2003). Thirty six percent of the phytoplankton and 5% of the zooplankton are estimated to be lost to the seabed annually. This natural annual input of millions of tons of organic material onto the seabed off the southern African West Coast has a substantial effect on the ecosystems of the Benguela region. It provides most of the food requirements of the particulate and filter-feeding benthic communities that inhabit the sandy-muds of this area, and results in the high organic content of the muds in the region. As most of the organic detritus is not directly consumed, it enters the seabed decomposition cycle, resulting in subsequent depletion of oxygen in deeper waters.

An associated phenomenon ubiquitous to the Benguela system are red tides (dinoflagellate and/or ciliate blooms) (see Shannon & Pillar 1985; Pitcher 1998). Also referred to as Harmful Algal Blooms (HABs), these red tides can reach very large proportions, extending over several square kilometres of ocean (Figure 3-5, left). Toxic dinoflagellate species can cause extensive mortalities of fish and shellfish through direct poisoning, while degradation of organic-rich material derived from both toxic and non-toxic blooms results in oxygen depletion of subsurface water (Figure 3-5, right).

Figure 3-5: Red tides can reach very large proportions (Left, Photo: www.e-education.psu.edu) and can lead to mass stranding, or 'walk-out' of rock lobsters, such as occurred at Elands Bay in February 2002 (Right, Photo: www.waterencyclopedia.com)

3.2.7 Low Oxygen Events

The continental shelf waters of the Benguela system are characterised by low oxygen concentrations with <40% saturation occurring frequently (e.g. Visser 1969; Bailey *et al.* 1985). The low oxygen concentrations are attributed to nutrient remineralisation in the bottom waters of the system (Chapman & Shannon 1985). The absolute rate of this is dependent upon the net organic material build-up in the sediments, with the carbon rich mud deposits playing an important role. As the mud on the shelf is distributed in discrete patches, there are corresponding preferential areas for the formation of oxygen-poor water. The two main areas of low-oxygen water formation in the southern Benguela region are in the Orange River Bight and St Helena Bay (Chapman & Shannon 1985; Bailey1991; Shannon & O'Toole 1998; Bailey 1999; Fossing *et al.* 2000). The spatial distribution of oxygen-poor water in each of the areas is subject to short- and medium-term variability in the volume of hypoxic water that develops. De Decker (1970) showed that the occurrence of low oxygen water off Lambert's Bay is seasonal, with highest development in summer/autumn. Bailey & Chapman (1991), on the other hand, demonstrated that in the St Helena Bay area daily variability exists as a result of downward flux of oxygen through thermoclines and short-term variations in upwelling intensity. Subsequent upwelling processes can move this low-oxygen water up onto the inner shelf, and into nearshore waters, often with devastating effects on marine communities.

Periodic low oxygen events in the nearshore region can have catastrophic effects on the marine communities leading to large-scale stranding of rock lobsters, and mass mortalities of marine biota and fish (Newman & Pollock 1974; Matthews & Pitcher 1996; Pitcher 1998; Cockcroft *et al.* 2000) (seeFigure 3-5, right). The development of anoxic conditions as a result of the decomposition of huge amounts of organic matter generated by algal blooms is the main cause for these mortalities and walkouts. The blooms develop over a period of unusually calm wind conditions when sea surface temperatures where high. Algal blooms usually occur during summer-autumn (February to April) but can also develop in winter during the 'berg' wind periods, when similar warm windless conditions occur for extended periods.

3.2.8 Turbidity

Turbidity is a measure of the degree to which the water loses its transparency due to the presence of suspended particulate matter. Total Suspended Particulate Matter (TSPM) can be divided into Particulate Organic Matter (POM) and Particulate Inorganic Matter (PIM), the ratios between them varying considerably. The POM usually consists of detritus, bacteria, phytoplankton and zooplankton, and serves as a source of food for filter-feeders. Seasonal microphyte production associated with upwelling events will play an important role in determining the concentrations of POM in coastal waters. PIM, on the other hand, is primarily of geological origin consisting of fine sands, silts and clays. Off Namaqualand, the PIM loading in nearshore waters is strongly related to natural inputs from the Orange River (Figure 3-6) or from 'berg' wind events(Figure 3-7). 'Berg' wind events can potentially contribute the same order of magnitude of sediment input as the annual estimated input of sediment by the Orange River (Shannon & Anderson 1982; Zoutendyk 1992, 1995; Shannon & O'Toole 1998; Lane & Carter 1999). For example,a 'berg' wind event in May 1979 described by Shannon and Anderson (1982) was estimated to have transported in the order of 50 million tons of sand out to sea, affecting an area of 20,000 km^2.

Concentrations of suspended particulate matter in shallow coastal waters can vary both spatially and temporally, typically ranging from a few mg/ℓ to several tens of mg/ℓ (Bricelj & Malouf 1984; Berg & Newell 1986; Fegley *et al.* 1992). Field measurements of TSPM and PIM concentrations in the Benguela current system have indicated that outside of major flood events, background concentrations of coastal and continental shelf suspended sediments are generally <12 mg/ℓ, showing significant long-shore variation (Zoutendyk 1995). Considerably higher concentrations of PIM have, however, been reported from southern African West Coast waters under stronger wave conditions associated with high tides and storms, or under flood conditions. During storm events, concentrations near the seabed may even reach up to 10,000 mg/ℓ (Miller & Sternberg 1988). In the vicinity of the Orange River mouth, where river outflow strongly influences the turbidity of coastal waters, measured concentrations ranged from 14.3 mg/ℓ at Alexander Bay just south of the mouth (Zoutendyk 1995) to peak values of 7,400 mg/ℓ immediately upstream of the river mouth during the 1988 Orange River flood (Bremner *et al.* 1990).

The major source of turbidity in the swell-influenced nearshore areas off the West Coast is the redistribution of fine inner shelf sediments by long-period Southern Ocean swells. The current velocities typical of the Benguela (10-30 cm/s) are capable of resuspending and transporting considerable quantities of sediment equatorwards. Under relatively calm wind conditions, however, much of the suspended fraction (silt and clay) that remains in suspension for longer periods becomes entrained in the slow poleward undercurrent (Shillington *et al.* 1990; Rogers & Bremner 1991).

Superimposed on the suspended fine fraction, is the northward littoral drift of coarser bedload sediments, parallel to the coastline. This northward, nearshore transport is generated by the predominantly south-westerly swell and wind-induced waves. Longshore sediment transport varies considerably in the shore-perpendicular dimension, being substantially higher in the surf zone than at depth, due to high turbulence and convective flows associated with breaking waves, which suspend and mobilise sediment (Smith & Mocke 2002).

Figure 3-6: Whale Head Minerals project area(red square) in relation to a substantial sediment plume emanating from the Orange River Mouth on 11 April 2001 (Satellite image source: eoimages.gsfc.nasa.gov).

Figure 3-7: Project area (red square) in relation to aerosol plumes of sand and dust due to a 'berg' wind event on the southern African west coast in October 2019 (Image Source: LandWaterSA).

On the inner and middle continental shelf, the ambient currents are insufficient to transport coarse sediments typical of those depths, and re-suspension and shoreward movement of these by wave-induced currents occur primarily under storm conditions (see also Drake *et al.* 1985; Ward 1985). Data from a Waverider buoy at Port Nolloth have indicated that 2-m waves are capable of re-suspending medium sands (200 µm diameter) at ~10 m depth, whilst 6-m waves achieve this at ~42 m depth. Low-amplitude, long-period waves will, however, penetrate even deeper. Most of the sediment shallower than 90 m can therefore be subject to re-suspension and transport by heavy swells (Lane & Carter 1999).

Mean sediment deposition is naturally higher near the seafloor due to constant re-suspension of coarse and fine PIM by tides and wind-induced waves. Aggregation or flocculation of small particles into larger aggregates occurs as a result of cohesive properties of some fine sediments in saline waters. The combination of re-suspension of seabed sediments by heavy swells, and the faster settling rates of larger inorganic particles, typically causes higher sediment concentrations near the seabed. Significant re-suspension of sediments can also occur up into the water column under stronger wave conditions associated with high tides and storms. Re-suspension can result in dramatic increases in PIM concentrations within a few hours (Sheng *et al*. 1994). Wind speed and direction have also been found to influence the amount of material re-suspended (Ward 1985).

Although natural turbidity of seawater is a global phenomenon, there has been a worldwide increase of water turbidity and sediment load in coastal areas as a consequence of anthropogenic activities. These include dredging associated with the construction of harbours and coastal installations, beach replenishment, accelerated runoff of eroded soils as a result of deforestation or poor agricultural practices, and discharges from terrestrial, coastal and marine mining operations (Airoldi 2003). Such increase of sediment loads has been recognised as a major threat to marine biodiversity at a global scale (UNEP 1995).

3.3. The Biological Environment

Biogeographically, the study area falls within the cold temperate Namaqua Bioregion (Emanuel *et al.*1992; Lombard *et al*. 2004), which in the 2018 National Biodiversity Assessment (Sink *et al*. 2019) is referred to as as a subregion of the Southern Benguela Shelf ecoregion(Figure 3-8). The coastal, wind-induced upwelling characterising the western Cape coastline, is the principle physical process which shapes the marine ecology of the southern Benguela region. The Benguela system is characterised by the presence of cold surface water, high biological productivity, and highly variable physical, chemical and biological conditions.The West Coast is, however, characterized by low marine species richness and low endemicity (Awad*et al*. 2002).

Communities within marine habitats are largely ubiquitous throughout the southern African West Coast region, being particular only to substrate type (i.e. hard vs. soft bottom), exposure to wave action, or water depth. These biological communities consist of many hundreds of species, often displaying considerable temporal and spatial variability (even at small scales). The mining targetarea extends from the high water mark on the coast to ~5 m depth.The benthic and coastal habitats of South Africa have been mapped by Sink *et al*. (2019). Those specific to the study area can be broadly grouped into:

- Sandy intertidal and unconsolidated subtidal substrates,and
- Intertidal rocky shores and subtidal reefs.

The biological communities ‘typical’ of these benthic habitats and the overlying water body are described briefly below, focussing both on dominant, commercially important and conspicuous species, as well as potentially threatened or sensitive species, which may be affected by the mining activities. No rare or endangered species have been recorded (Awad *et al*. 2002).

Figure 3-8: Walviskop project area (red square) in relation tothe South African ecoregions (adapted from Sink *et al*. 2019).

3.3.1Sandy and Unconsolidated Habitats and Biota

The benthic biota of unconsolidated marine sediments constitute invertebrates that live on (epifauna) or burrow within (infauna) the sediments, and are generally divided into macrofauna (animals >1 mm) and meiofauna (<1 mm).

The coastlinefrom the Orange River mouth to Kleinzee is dominated by rocky shores, interspersed by isolated short stretches of sandy shores. Sandy beaches are one of the most dynamic coastal environments. With the exception of a few beaches in large bay systems (such as St Helena Bay, Saldanha Bay, Table Bay), the beaches along the South African west coast are typically highly exposed. Exposed sandy shores consist of coupled surf zone, beach and dune systems, which together form the active littoral sand transport zone (Short & Hesp 1985). The composition of their faunal communities is largely dependent on the interaction of wave energy, beach slope and sand particle size, which is termed beach morphodynamics. Three morphodynamic beach types are described: dissipative, reflective and intermediate beaches (McLachlan *et al*. 1993). Generally, dissipative beaches are relatively wide and flat with fine sands and low wave energy. Waves start to break far from the shore in a series of spilling breakers that 'dissipate' their energy along a broad surf zone.This generates slow swashes with long periods, resulting in less turbulent conditions on the gently sloping beach face. These beaches usually harbour the richest intertidal faunal communities.

Reflective beaches in contrast, have high wave energy, and are coarse grained (>500 µm sand) with narrow and steep intertidal beach faces. The relative absence of a surf zone causes the waves to break directly on the shore causing a high turnover of sand. The result is depauperate faunal communities. Intermediate beach conditions exist between these extremes and have a very variable species composition (McLachlan *et al.*1993; Jaramillo *et al.* 1995, Soares 2003). This variability is mainly attributable to the amount and quality of food available. Beaches with a high input of e.g. kelp wrack have a rich and diverse drift-line fauna, which is sparse or absent on beaches lacking a drift-line (Branch & Griffiths 1988). As a result of the combination of typical beach characteristics, and the special adaptations of beach fauna to these, beaches act as filters and energy recyclers in the nearshore environment (Brown & McLachlan 2002).

Numerous methods of classifying beach zonation have been proposed, based either on physical or biological criteria. The general scheme proposed by Branch & Griffiths (1988) is used below (Figure 3-9), supplemented by data from various publications on West Coast sandy beach biota (e.g. Bally 1987; Brown *et al.* 1989; Soares *et al.* 1996, 1997; Nel 2001; Nel *et al.* 2003; Soares 2003;Branch *et al.* 2010; Harris 2012). The macrofaunal communities of sandy beaches are generally ubiquitous throughout the southern African West Coast region, being particular only to substratum type, wave exposure and/or depth zone. Due to the exposed nature of the coastline in the study area, most beaches are of the intermediate to reflective type. The supralittoral zone is situated above the high water spring (HWS) tide level, and receives water input only from large waves at spring high tides or through sea spray. This zone is characterised by a mixture of air breathing terrestrial and semi-terrestrial fauna, often associated with and feeding on kelp deposited near or on the driftline. Terrestrial species include a diverse array of beetles and arachnids and some oligochaetes, while semi-terrestrial fauna include the oniscid isopod *Tylos granulatus*, and amphipods of the genus *Talorchestia*. The intertidal zone or mid-littoral zone has a vertical range of about 2 m. This mid-shore region is characterised by the cirolanid isopods *Pontogeloideslatipes*, *Eurydice* (*longicornis*=) *kensleyi*, and *Excirolananatalensis*, the polychaetes *Scolelepissquamata*, *Orbiniaangrapequensis*, *Nepthyshombergii* and *Lumbrineristetraura*, and amphipods of the families Haustoridae and Phoxocephalidae (Figure 3-10). In some areas, juvenile and adult sand mussels *Donax serra* may also be present in considerable numbers.

The inner turbulent zone extends from the Low Water Spring mark to about -2 m depth. The mysid *Gastrosaccus psammodytes* (Mysidacea, Crustacea), the ribbon worm *Cerebratulus fuscus* (Nemertea), the cumacean *Cumopsis robusta* (Cumacea) and a variety of polychaetes including *Scolelepis squamata* and *Lumbrineris tetraura*, are typical of this zone, although they generally extend partially into the midlittoral above. In areas where a suitable swash climate exists, the gastropod *Bullia digitalis* (Gastropoda, Mollusca) may also be present in considerable numbers, surfing up and down the beach in search of carrion.

The transition zone spans approximately 2-5 m depth beyond the inner turbulent zone. Extreme turbulence is experienced in this zone, and as a consequence this zone typically harbours the lowest diversity on sandy beaches. Typical fauna include amphipods such as *Cunicus profundus* and burrowing polychaetes such as *Cirriformia tentaculata* and *Lumbrineris tetraura.*

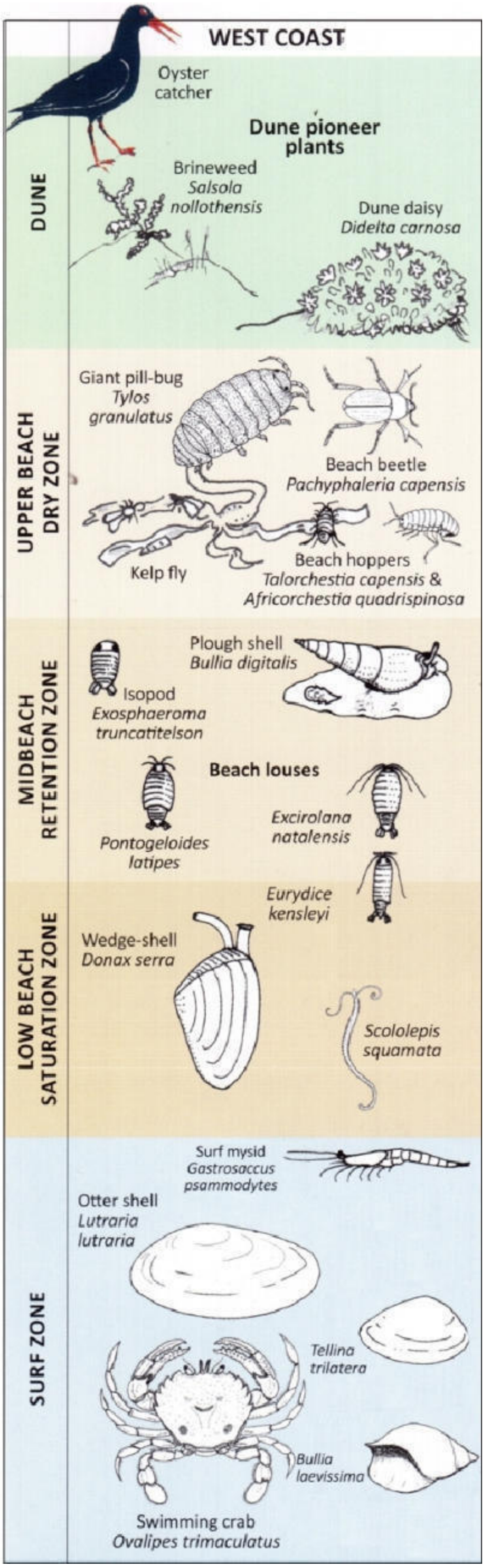


Figure 3-9: Schematic representation of the West Coast intertidal beach zonation (adapted from Branch & Branch 2018). Species commonly occurring on the Namaqualand beaches are listed.

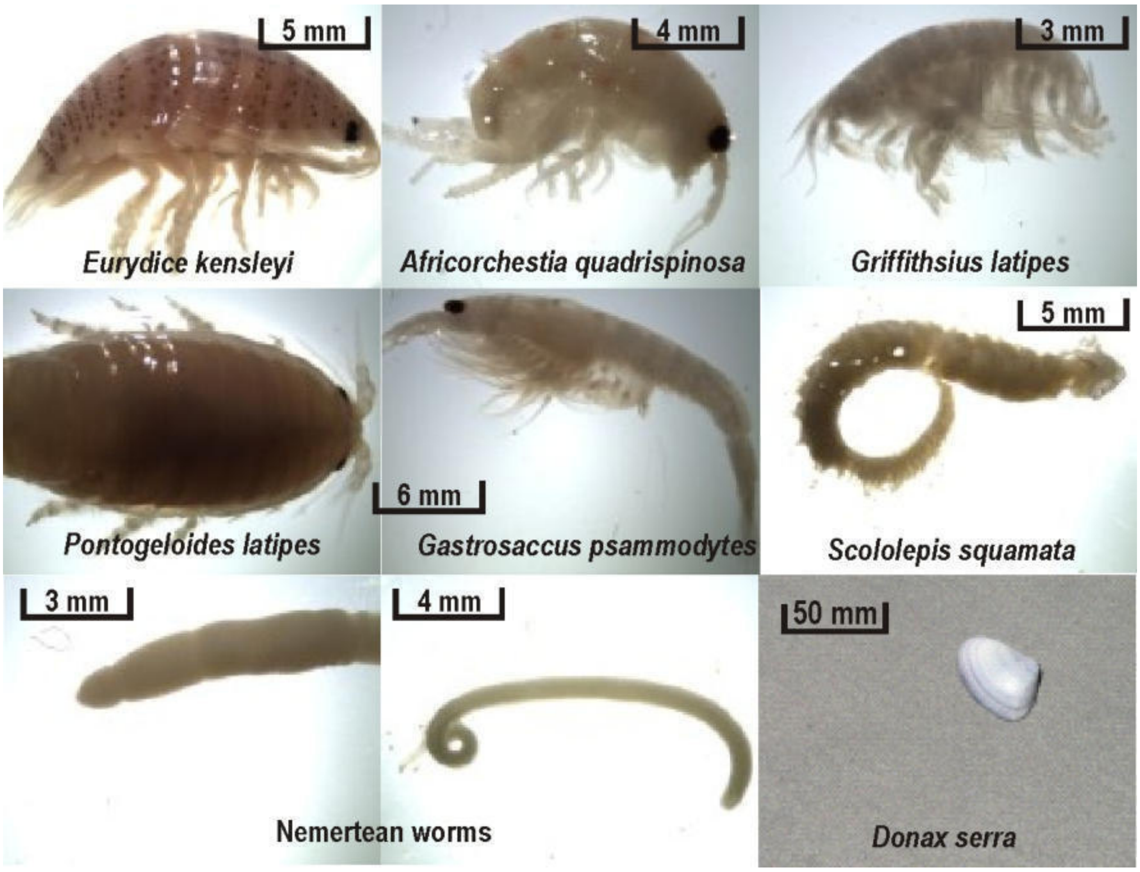
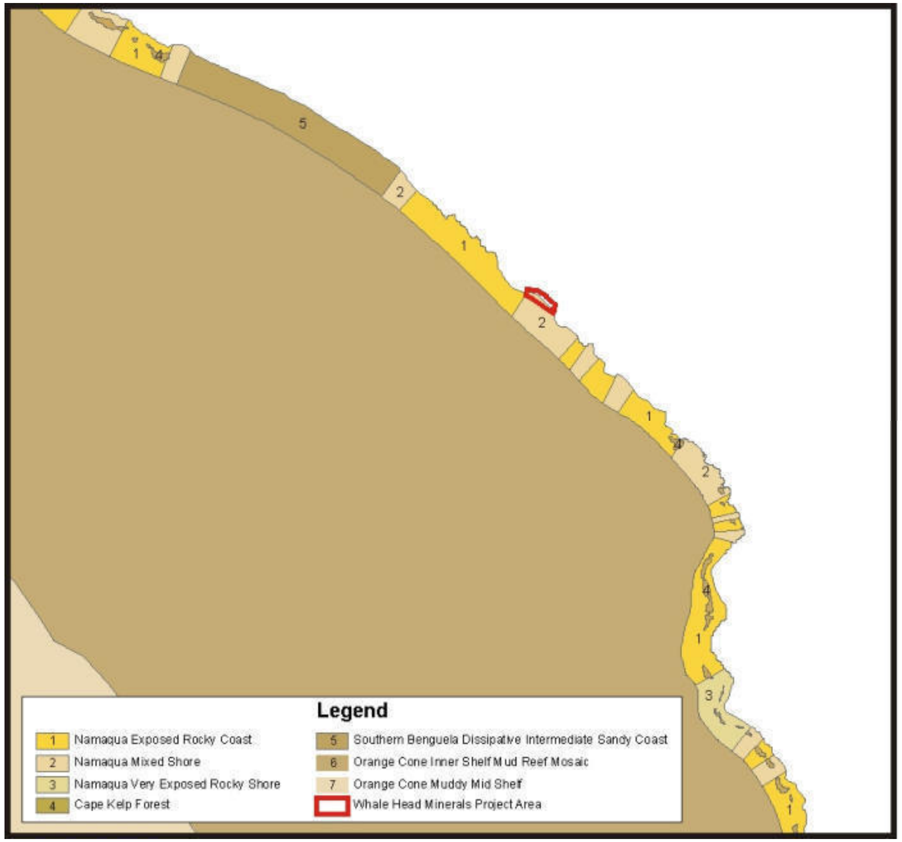


Figure 3-10: Common beach macrofaunal species occurring on exposed West Coast beaches.

The outer turbulent zone extends below 5 m depth, where turbulence is significantly decreased and species diversity is again much higher. In addition to the polychaetes found in the transition zone, other polychaetes in this zone include *Pectinaria capensis*, and *Sabellides ludertizii*. The sea pen V*irgularia schultzi* (Pennatulacea, Cnidaria) is also common as is a host of amphipod species and the three spot swimming crab *Ovalipes punctatus* (Brachyura, Crustacea).

The marine component of the 2018 National Biodiversity Assessment (Sink *et al.* 2019), rated portions of the inner continental shelf on the West Coast as 'endangered', whereas sections of the coastline in the broader project area are rated as either 'vulnerable' or of 'least concern' (Figure 3-11) (see Table 3-6). Those habitat types within the general project area are alsoillustrated inFigure 3-11.



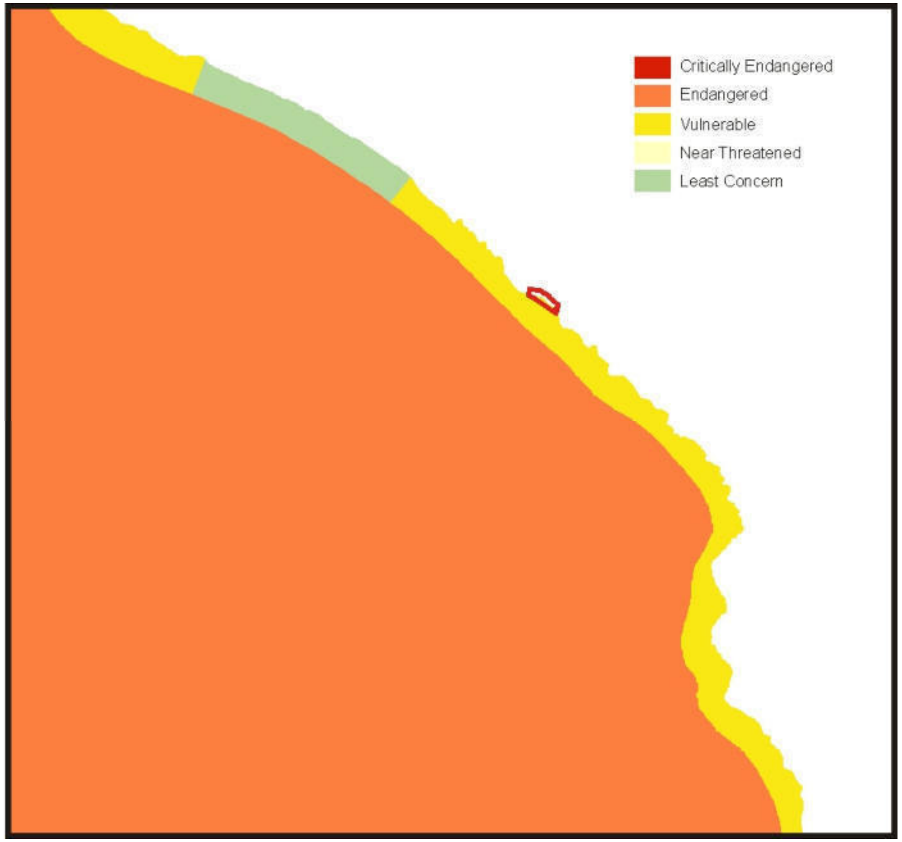


Figure 3-11: Whale Head Minerals proposed mining area (red polygon) in relation to the marine ecosystem types (left) and the ecosystem threat status (right) for coastal and offshore ecosystem types in the borader project area (adapted from Sink *et al*. 2019).

3.3.2 Rocky Substrate Habitats and Biota

The following general description of the intertidal and subtidal habitats for the West Coast is based on Field *et al.* (1980), Branch & Griffiths (1988), Field & Griffiths (1991) and Branch & Branch (2018).

3.3.2.1 Intertidal Rocky Shores

Several studies on the west coast of southern Africa have documented the important effects of wave action on the intertidal rocky-shore community. Specifically, wave action enhances filter-feeders by increasing the concentration and turnover of particulate food, leading to an elevation of overall biomass despite a low species diversity (McQuaid & Branch 1985, Bustamante & Branch 1995a, 1996a, Bustamante *et al.* 1997). Conversely, sheltered shores are diverse with a relatively low biomass, and only in relatively sheltered embayments does drift kelp accumulate and provide a vital support for very high densities of kelp trapping limpets, such as *Cymbula granatina* that occur exclusively there (Bustamante *et al.* 1995). In the subtidal, these differences diminish as wave exposure is moderated with depth.

West Coast rocky intertidal shores can be divided into five zones on the basis of their characteristic biological communities: The Littorina, Upper Balanoid, Lower Balanoid, Cochlear/Argenvillei and the Infratidal Zones. These biological zones correspond roughly to zones based on tidal heights (Figure 3-12 and Figure 3-13). Tolerance to the physical stresses associated with life on the intertidal, as well as biological interactions such as herbivory, competition and predation interact to produce these five zones.

The uppermost part of the shore is the supralittoral fringe, which is the part of the shore that is most exposed to air, perhaps having more in common with the terrestrial environment. The supralittoral is characterised by low species diversity, with the tiny periwinkle *Afrolittorina knysnaensis*, and the red alga *Porphyra capensis* constituting the most common macroscopic life.

The upper mid-littoral is characterised by the limpet *Scutellastra granularis*, which is present on all shores. The gastropods *Oxystele variegata*, *Nucella dubia*, and *Helcion pectunculus* are variably present, as are low densities of the barnacles *Tetraclita serrata*, *Octomeris angulosa* and*Chthalamus dentatus*. Flora is best represented by the green algae *Ulva* spp.

Toward the lower Mid-littoral or Lower Balanoid zone, biological communities are determined by exposure to wave action. On sheltered and moderately exposed shores, a diversity of algae abounds with a variable representation of: green algae – *Ulva* spp, *Codium* spp.; brown algae – *Splachnidium rugosum*; and red algae – *Aeodes orbitosa*, *Mazzaella (=Iridaea) capensis*, *Gigartina polycarpa* (=*radula*), *Sarcothalia* (=*Gigartina*) *stiriata*, and with increasing wave exposure *Plocamium rigidum* and *P. cornutum*, and *Champia lumbricalis*. The gastropods *Cymbula granatina* and *Burnupena* spp. are also common, as is the reef building polychaete *Gunnarea capensis*, and the small cushion starfish *Patiriella exigua*. On more exposed shores, almost all of the primary space can be occupied by the dominant alien invasive mussel *Mytilus galloprovincialis*. First recorded in 1979 (although it is likely to have arrived in the late 1960s), it is now the most abundant and widespread invasive marine species spreading along the entire West Coast and parts of the South Coast (Robinson *et al.*2005). *M. galloprovincialis*has partially displaced thelocal mussels *Choromytilusmeridionalis* and *Aulacomyaater*

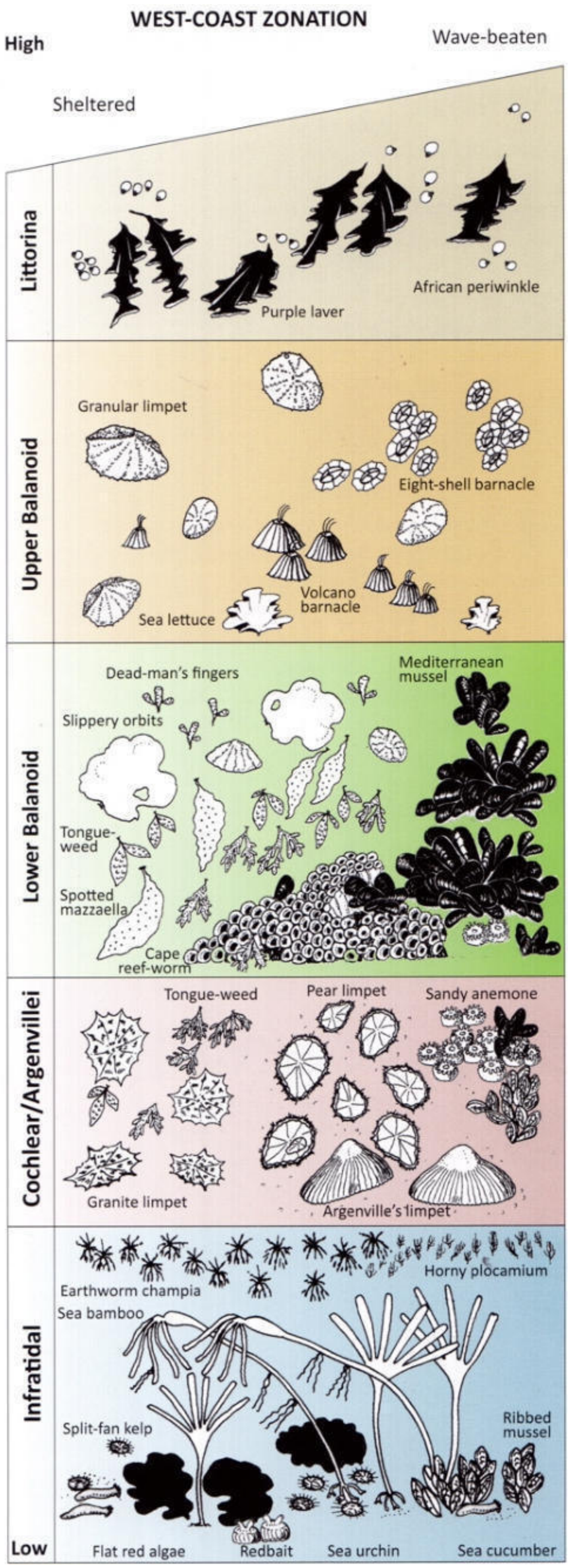


Figure 3-12: Schematic representation of the West Coast intertidal zonation (adapted from Branch & Branch 2018).

(Hockey & Van ErkomSchurink 1992), and competes with several indigenous limpet species (Griffiths *et al*. 1992; Steffani & Branch 2003a, b). Another alien invasive recorded in the past decade is the acorn barnacle *Balanus glandula*, which is native to the west coast of North America where it is the most common intertidal barnacle (Simon-Blecher *et al*. 2008). There is, however, evidence that it has been in South Africa since at least 1992 (Laird & Griffith 2008). At the time of its discovery, the barnacle was recorded from 400 km of coastline from Misty Cliffs near Cape Point to Elands Bay (Laird & Griffith 2008). It has been reported on rocky shores as far north as Lüderitz in Namibia (Pulfrich 2016), and was identified in the Alexkor mining licence area 554MRC during a site visit in July 2017. When present, the barnacle is typically abundant at the mid zones of semi-exposed shores.

Figure 3-13: Typical rocky intertidal zonation on the southern African west coast.

Along the sublittoral fringe, the large kelp-trapping limpet *Scutellastra argenvillei* dominates forming dense, almost monospecificstands achieving densities of up to 200/m^2 (Bustamante *et al*. 1995). Similarly, *C. granatina* is the dominant grazer on more sheltered shores, also reaching extremely high densities (Bustamante *et al*. 1995). On more exposed shores *M. galloprovincialis* dominates. There is evidence that the arrival of the alien *M. galloprovincialis* has led to strong competitive interaction with *S. argenvillei* (Steffani & Branch 2003a, 2003b, 2005). The abundance of the mussel changes with wave exposure, and at wave-exposed locations, the mussel can cover almost the entire primary substratum,whereas in semi-exposed situations it is never abundant. As the cover of *M. galloprovincialis* increases, theabundance and size of *S. argenvillei* on rock declines and it becomes confined to patches within a matrix of musselbed. As a result exposed sites, once dominatedby dense populations of the limpet, are nowlargely covered by the alien mussel.Semi-exposed shores do, however, offer a refugepreventing global extinction of the limpet. In addition to the mussel and limpets, there is variable representation of the flora and fauna described for the lower mid-littoral above, as well as the anemone *Aulactinia reynaudi*, numerous whelk species and the sea urchin *Parechinus angulosus*. Some of these species extend into the subtidal below.

More recently, the invasion of west coast rocky shores by another mytilid, the hermaphroditic Chilean*Semimytilus algosus*, was noted (de Greef *et al.* 2013). It is hypothesized that this species wasintroduced either by shipping traffic from Namibia(Walvis Bay and Swakopmund) or through the importing of oyster spat from Chile for mariculture purposes. First reported in 2009 from Elands Bay, its distribution spread rapidly to cover 500 km of coastline within a few years (de Greef *et al.* 2013). Its current range extends from Lüderitz(pers. obs) to Bloubergstrand in the south. Where present, it occupies the lower intertidal zone completely dominating primary rock space, while *M. galloprovincialis* dominates higher up the shore. Many shores on the West Coast have thus now been effectively partitioned by the three introduced species, with *B. glandula* colonizing the upper intertidal, *M. galloprovincialis* dominating the mid-shore, and now *S. algosus* smothering the low-shore (de Greef *et al.* 2013).The shells of *S. algosus*are, however, typically thin and weak, and have a low attachment strength to the substrate, thereby making the species vulnerable to predators, interference competition, desiccation and the effects of wave action (Zeeman 2016). The competitive ability of *S. algosus* is strongly related to shore height. Due to intolerance to desiccation, it cannot survive on the high shore, but on the low shore its high recruitment rate offsets the low growth rate, and high mortality rate as a result of wave action and predation.

Most of the rocky shores in the southern portion of 554MRC and in the Walviskop project area will be similar to 'typical' shores as described above, although those in the centre of the target beach are expected to show evidence of sand scouring and periodic sand inundation. Such shores will harbour more sand-tolerant and opportunistic foliose algal genera (e.g. *Ulva* spp.,*Grateloupiabelangeri, Nothogenia erinacea)*many of which have mechanisms of growth, reproduction and perennation that contribute to their persistence on sand-influenced shores (Daly & Matheison 1977; Airoldi *et al.* 1995; Anderson *et al.* 2008). Of the benthic fauna, the sand-tolerant anemone *Bunodactis reynaudi*, the Cape reef worm *Gunnarea gaimardi*, and the siphonarid *Siphonaria capensis*were prevalent, with the anemone in particular occupying much of the intertidal space.

3.3.2.2 Rocky Subtidal Habitat and Kelp Beds

Biological communities of the rocky sublittoral can be broadly grouped into an inshore zone from the sublittoral fringe to a depth of about 10 m dominated by flora, and an offshore zone below 10 m depth dominated by fauna. This shift in communities is not knife-edge, and rather represents a continuum of species distributions, merely with changing abundances.

From the sublittoral fringe to a depth of between 5 and 10 m, the benthos is largely dominated by algae, in particular two species of kelp. The canopy forming kelp *Ecklonia maxima* extends seawards to a depth of about 10 m. The smaller *Laminaria pallida* forms a sub-canopy to a height of about 2 m underneath *Ecklonia*, but continues its seaward extent to about 30 m depth, although in the northern regions of the west coast, and in the coastal mining licence areas, increasing turbidity limits growth to shallower waters (10-20 m) (Velimirov *et al.* 1977; Jarman & Carter 1981; Branch 2008). *Ecklonia maxima* is the dominant species in the south forming extensive beds from west of Cape Agulhas to north of Cape Columbine, but decreasing in abundance northwards. *Laminaria* becomes the dominant kelp north of Cape Columbine and thus in the project area, extending from Danger Point east of Cape Agulhas to Rocky Point in northern Namibia (Stegenga *et al*. 1997; Rand 2006).

Kelp beds absorb and dissipate much of the typically high wave energy reaching the shore, thereby providing important partially-sheltered habitats for a high diversity of marine flora and fauna, resulting in diverse and typical kelp-forest communities being established (Figure 3-14). Through a combination of shelter and provision of food, kelp beds support recruitment and complex trophic food webs of numerous species, including commercially important rock lobster stocks (Branch 2008).

Figure 3-14: The canopy-forming kelp *Ecklonia maxima* provides an important habitat for a diversity of marine biota (Photos: West Coast Abalone).

Growing beneath the kelp canopy, and epiphytically on the kelps themselves, are a diversity of understorey algae, which provide both food and shelter for predators, grazers and filter-feeders associated with the kelp bed ecosystem. Representative under-storey algae include *Botryocarpa prolifera*, *Neuroglossum binderianum*, *Botryoglossum platycarpum*, *Hymenena venosa* and *Rhodymenia* (=*Epymenia*) *obtusa*, various coralline algae, as well as subtidal extensions of some algae occurring primarily in the intertidal zones (Bolton 1986). Epiphytic species include *Polysiphonia virgata*, *Gelidium vittatum (=Suhria vittata)* and *Carpoblepharis flaccida*. In particular, encrusting coralline algae are important in the under-storey flora as they are known as settlement attractors for a diversity of invertebrate species. The presence of coralline crusts is thought to be a key factor in supporting a rich shallow-water community by providing substrate, refuge, and food to a wide variety of infaunal and epifaunal invertebrates (Chenelot *et al*. 2008).

The sublittoral invertebrate fauna is dominated by suspension and filter-feeders, such as the mussels *Aulacomya ater* and *Choromytilus meriodonalis*, and the Cape reef worm *Gunnarea gaimardi*, and a variety of sponges and sea cucumbers. Grazers are less common, with most herbivory being restricted to grazing of juvenile algae or debris-feeding on detached macrophytes. The dominant herbivore is the sea urchin *Parechinus angulosus*, with lesser grazing pressure from limpets, the isopod *Paridotea reticulata* and the amphipod *Ampithoe humeralis*. The abalone *Haliotis midae*, an important commercial species present in kelp beds south of Cape Columbine is naturally absent north of Cape Columbine, although attempts at ranching this species along the Namaqualand coast are currently underway. Key predators in the sub-littoral include the commercially important West Coast rock lobster *Jasus lalandii* and the octopus *Octopus vulgaris*. The rock lobster acts as a keystone species as it influences community structure *via* predation on a wide range of benthic organisms (Mayfield *et al*. 2000). Relatively abundant rock lobsters can lead to a reduction in density, or even elimination, of black mussel *Choromytilus meriodonalis*, the preferred prey of the species, and alter the size structure of populations of ribbed mussels *Aulacomya ater*, reducing the proportion of selected size-classes (Griffiths & Seiderer 1980). Their role as predator can thus reshape benthic communities, resulting in large reductions in taxa such as black mussels, urchins, whelks and barnacles, and in the dominance of algae (Barkai & Branch 1988; Mayfield 1998).

Of lesser importance as predators, although numerically significant, are various starfish, feather and brittle stars, and gastropods, including the whelks *Nucella* spp. and *Burnupena* spp. Fish species commonly found in kelp beds off the West Coast include hottentot *Pachymetopon blochii*, two tone finger fin *Chirodactylus brachydactylus*, red fingers *Cheilodactylus fasciatus*, galjoen *Dichistius capensis*, rock suckers *Chorisochismus dentex* and the catshark *Haploblepharus pictus* (Branch *et al*. 2010).

There is substantial spatial and temporal variability in the density and biomass of kelp beds, as storms can remove large numbers of plants and recruitment appears to be stochastic and unpredictable (Levitt *et al*. 2002; Rothman *et al*. 2006). Some kelp beds are dense, whilst others are less so due to differences in seabed topography, and the presence or absence of sand and grazers.

3.3.3 The Water Body

In contrast benthic biota which are associated with the seabed, pelagic species live and feed in the open water column. The pelagic communities are typically divided into plankton and fish, and their main predators, marine mammals (seals, dolphins and whales), seabirds and turtles.

3.3.3.1 Plankton

Plankton is particularly abundant in the shelf waters off the West Coast, being associated with the upwelling characteristic of the area. Plankton range from single-celled bacteria to jellyfish of 2-m diameter, and include bacterio-plankton, phytoplankton, zooplankton, and ichthyoplankton (Figure 3-15).

Figure 3-15: Phytoplankton (left, photo: hymagazine.com) and zooplankton (right, photo: mysciencebox.org) is associated with upwelling cells.

Phytoplankton are the principle primary producers with mean productivity ranging from 2.5 - 3.5 g C/m^2/day for the midshelf region and decreasing to 1 g C/m^2/day inshore of 130 m (Shannon & Field 1985; Mitchell-Innes & Walker 1991; Walker & Peterson 1991). The phytoplankton is dominated by large-celled organisms, which are adapted to the turbulent sea conditions. The most common diatom genera are *Chaetoceros*, *Nitschia*, *Thalassiosira*, *Skeletonema*, *Rhizosolenia*, *Coscinodiscus* and *Asterionella* (Shannon & Pillar 1985). Diatom blooms occur after upwelling events, whereas dinoflagellates (e.g. *Prorocentrum*, *Ceratium* and *Peridinium*) are more common in blooms that occur during quiescent periods, since they can grow rapidly at low nutrient concentrations. In the surf zone, diatoms and dinoflagellates are nearly equally important members of the phytoplankton, and some silicoflagellates are also present.

Red-tides are ubiquitous features of the Benguela system (see Shannon & Pillar 1986). The most common species associated with red tides (dinoflagellate and/or ciliate blooms) are *Noctiluca scintillans*, *Gonyaulax tamarensis*, *G. polygramma* and the ciliate *Mesodinium rubrum*. *Gonyaulax* and *Mesodinium* have been linked with toxic red tides. Most of these red-tide events occur quite close inshore although Hutchings *et al.*(1983) have recorded red-tides 30 km offshore.

The mesozooplankton (≥200µm) is dominated by copepods, which are overall the most dominant and diverse group in southern African zooplankton. Important species are *Centropagesbrachiatus*, *Calanoidescarinatus*, *Metridialucens*, *Nannocalanusminor*, *Clausocalanus arcuicornis*, *Paracalanus parvus*, *P. crassirostris* and *Ctenocalanus vanus*. All of the above species typically occur in the phytoplankton rich upper mixed layer of the water column, with the exception of *M. lucens* which undertakes considerable vertical migration.

The macrozooplankton (≥1,600µm) are dominated by euphausiids of which 18 species occur in the area. The dominant species occurring in the nearshore are *Euphausia lucens* and *Nyctiphanes capensis*, although neither species appears to survive well in waters seaward of oceanic fronts over the continental shelf (Pillar *et al.* 1991).

Standing stock estimates of mesozooplankton for the southern Benguela area range from 0.2 - 2.0 g C/m^2, with maximum values recorded during upwelling periods. Macrozooplankton biomass ranges from 0.1-1.0 g C/m^2, with production increasing north of Cape Columbine (Pillar 1986). Although it shows no appreciable onshore-offshore gradients, standing stock is highest over the shelf, with accumulation of some mobile zooplanktors (euphausiids) known to occur at oceanographic fronts. Beyond the continental slope biomass decreases markedly.

Zooplankton biomass varies with phytoplankton abundance and, accordingly, seasonal minima will exist during non-upwelling periods when primary production is lower (Brown 1984; Brown & Henry 1985), and during winter when predation by recruiting anchovy is high. More intense variation will occur in relation to the upwelling cycle; newly upwelled water supporting low zooplankton biomass due to paucity of food, whilst high biomasses develop in aged upwelled water subsequent to significant development of phytoplankton. Irregular pulsing of the upwelling system, combined with seasonal recruitment of pelagic fish species into West Coast shelf waters during winter, thus results in a highly variable and dynamic balance between plankton replenishment and food availability for pelagic fish species.

The project area lies within the influence of the Namaquaupwelling cell, and seasonally high phytoplankton abundance can be expected, providing favourable feeding conditions for micro-, meso- and macrozooplankton, and for ichthyoplankton.Although ichthyoplankton (fish eggs and larvae) comprise a minor component of the overall plankton, it remains significant due to the commercial importance of the overall fishery in the region. Various pelagic and demersal fish species are known to spawn in the inshore regions of the southern Benguela (Crawford *et al.* 1987), and their eggs and larvae form an important contribution to the ichthyoplankton in the region. However, in the Orange River Cone area immediately to the north of the upwelling cell, high turbulence and deep mixing in the water column result in diminished phytoplankton biomassand consequently the area is considered to be an environmental barrier to the transport of ichthyoplankton from the southern to the northern Benguela upwelling ecosystems.Important pelagic fish species, including anchovy, redeye round herring, horse mackerel and shallow-water hake, are reported as spawning on either side of the Orange River Cone area, but not within it. Ichthyoplankton abundances in the project area are thus expected to be comparatively low.

3.3.3.2 Pelagic Fish

The structure of the nearshore and surf zone fish community varies greatly with the degree of wave exposure. Species richness and abundance is generally high in sheltered and semi-exposed areas but typically very low off the more exposed beaches (Clark 1997a, 1997b). The surf zone and outer turbulent zone habitats of sandy beaches are considered to be important nursery habitats for marine fishes (Modde 1980; Lasiak 1981; Kinoshita & Fujita 1988; Clark *et al*. 1994). However, the composition and abundance of the individual assemblages seems to be heavily dependent on wave exposure (Blaber & Blaber 1980, Potter *et al*. 1990, Clark 1997a, 1997b). Surf zone fish communities off the South African West Coast have relatively high biomass, but low species diversity. Typical surf zone fish include harders (*Liza richardsonii*), white stumpnose (*Rhabdosargus globiceps*) (Figure 3-16), Cape sole (*Heteromycteris capensis*), Cape gurnard (*Chelidonichthys capensis*),False Bay klipfish (*Clinus latipennis*), sandsharks (*Rhinobatosannulatus*), eagle ray(*Myliobatis aquila*),and smooth-hound (*Mustelus mustelus*) (Clark 1997b).

Fish species commonly found in kelp beds off the West Coast include hottentot *Pachymetopon blochii* (Figure 3-17, left), twotone fingerfin *Chirodactylus brachydactylus*(Figure 3-17, right), red fingers *Cheilodactylus fasciatus*, galjoen *Dichistius capensis*, rock suckers *Chorisochismus dentex,* maned blennies *Scartella emarginata* and the catshark *Haploblepharus pictus* (Sauer*et al.*1997; Brouwer *et al*. 1997; Branch *et al*. 2010).

Figure 3-16: Common surf zone fish include the harder (left, photo: aquariophil.org) and the white stumpnose (right, photo: easterncapescubadiving.co.za).


Figure 3-17: Common fish found in kelp beds include the Hottentot fish (left, photo: commons. wikimedia.org) and the twotone fingerfin (right, photo:www.parrphotographic.com).

Small pelagic species occurring beyond the surfzone and generally within the 200 m contour include the sardine/pilchard (*Sadinops ocellatus*) (Figure 3-18, left), anchovy (*Engraulis capensis*), chub mackerel (*Scomber japonicus*), horse mackerel (*Trachurus capensis*) (Figure 3-18, right) and round herring (*Etrumeus whiteheadi*). These species typically occur in mixed shoals of various sizes (Crawford *et al*. 1987), and exhibit similar life history patterns involving seasonal migrations between the west and south coasts. The spawning areas of the major pelagic species are distributed on the continental shelf and along the shelf edge from south of St Helena Bay to Mossel Bay on the South Coast (Shannon & Pillar 1986). They spawn downstream of major upwelling centres in spring and summer, and their eggs and larvae are subsequently carried around Cape Point and up the coast in northward flowing surface waters.


Figure 3-18: Cape fur seal preying on a shoal of pilchards (left). School of horse mackerel (right) (photos: www.underwatervideo.co.za; www.delivery.superstock.com).

At the start of winter every year, juveniles of most small pelagic shoaling species recruit into coastal waters in large numbers between the Orange River and Cape Columbine. They recruit in the pelagic stage, across broad stretches of the shelf, to utilise the shallow shelf region as nursery grounds before gradually moving southwards in the inshore southerly flowing surface current, towards the major spawning grounds east of Cape Point. Recruitment success relies on the interaction of oceanographic events, and is thus subject to spatial and temporal variability. Consequently, the abundance of adults and juveniles of these small, short-lived (1-3 years) pelagic fish is highly variable both within and between species.

Two species that migrate along the West Coast following the shoals of anchovy and pilchards are snoek *Thyrsites atun* and chub mackerel *Scomber japonicas*. Their appearance along the West and South-West coasts are highly seasonal. Snoek migrating along the southern African West Coast reach the area between St Helena Bay and the Cape Peninsula between May and August. They spawn in these waters between July and October before moving offshore and commencing their return northward migration (Payne & Crawford 1989). They are voracious predators occurring throughout the water column, feeding on both demersal and pelagic invertebrates and fish. Chub mackerel similarly migrate along the southern African West Coast reaching South-Western Cape waters between April and August. They move inshore in June and July to spawn before starting the return northwards offshore migration later in the year. Their abundance and seasonal migrations are thought to be related to the availability of their

3.3.3.3 Turtles

Three species of turtle occur along theWest Coast, namely the Leatherback (*Dermochelys coriacea*) (Figure 3-19, left), and occasionallythe Loggerhead (*Caretta caretta*) (Figure 3-19, right) and the Green (*Chelonia mydas*) turtle. Loggerhead and Green turtles are expected to occur only as occasional visitors along the West Coast.

Figure 3-19: Leatherback (left) and loggerhead turtles (right) occur along the West Coast of Southern Africa (Photos: Ketos Ecology 2009; www.aquaworld-crete.com).

The Leatherback is the only turtle likely to be encountered in the offshore waters of west South Africa. The Benguela ecosystem, especially the northern Benguela where jelly fish numbers are high, is increasingly being recognized as a potentially important feeding area for leatherback turtles from several globally significant nesting populations in the south Atlantic (Gabon, Brazil) and south east Indian Ocean (South Africa) (Lambardi *et al*. 2008, Elwen &Leeney 2011). Leatherback turtles from the east South Africa population have been satellite tracked swimming around the west coast of South Africa and remaining in the warmer waters west of the Benguela ecosystem (Lambardi *et al*. 2008).

Leatherback turtles inhabit deeper waters and are considered a pelagic species, travelling the ocean currents in search of their prey (primarily jellyfish). While hunting they may dive to over 600 m and remain submerged for up to 54 minutes (Hays *et al*. 2004). Their abundance in the study area is unknown but expected to be low. Leatherbacks feed on jellyfish and are known to have mistaken plastic marine debris for their natural food. Ingesting this can obstruct the gut, lead to absorption of toxins and reduce the absorption of nutrients from their real food. Leatherback Turtles are listed as "Critically Endangered" worldwide by the IUCN and are in the highest categories in terms of need for conservation in CITES (Convention on International Trade in Endangered Species), and Convention on Migratory Species. Loggerhead and green turtles are listed as "Endangered". As a signatory of the Convention on Migratory Species, South Africa has endorsed and signed an International Memorandum of Understanding specific to the conservation of marine turtles. South Africa is thus committed to conserve these species at an international level.

3.3.3.4 Seabirds

14 species of seabirds breed in southern Africa; Cape Gannet, African Penguin, four species of Cormorant, White Pelican, three Gull and four Tern species (

Table 3-1). Birds endemic to the region and liable to occur most frequently in the project area include Cape Gannets, Kelp Gulls, African Penguins, African Black Oystercatcher (Figure 3-20, left), Bank, Cape and Crowned Cormorants (Figure 3-20, right), and Hartlaub's Gull. Of these the Black oystercatcher and Bank cormorant are rare. The breeding success of African Black Oystercatcher is particularly susceptible to disturbance from off-road vehicles as they nest and breed on beaches between the Eastern Cape and southern Namibia. Caspian and Damara terns are likewise rare and breed in the broader study area, especially in the wetland and saltpan areas associated with the Orange River and OlifantsRiver estuaries.

Most of the breeding seabird species forage at sea with most birds being found relatively close inshore (10-30 km), although African Penguins and Cape Gannets are known to forage up to 60 km and 140 km offshore, respectively (Dundee 2003; Ludynia 2007).

There are no seabird breeding sites in the vicinity of the Walviskop project area, other than the RAMSAR site at the Orange River mouth, some 60 km to the north.

Figure 3-20: The African Black Oystercatcher (Left, photo: patrickspilsbury.blogspot.com) and Crowned Cormorant (right, photo: savoels.za.net) occur in the project area.

Table 3-1: Breeding resident seabirds present along the West Coast (CCA & CMS 2001).

Common name	Species name	RSA Regional Assessment
African Penguin	*Spheniscus demersus*	Endangered
Great Cormorant	*Phalacrocorax carbo*	Least Concern
Cape Cormorant	*Phalacrocorax capensis*	Endangered
Bank Cormorant	*Phalacrocorax neglectus*	Endangered
Crowned Cormorant	*Microcarbo coronatus*	Near Threatened
White Pelican	*Pelecanus onocrotalus*	Vulnerable
Cape Gannet	*Morus capensis*	Endangered
Kelp Gull	*Larus dominicanus*	Least Concern
Greyheaded Gull	*Larus cirrocephalus*	Least Concern
Hartlaub's Gull	*Larus hartlaubii*	Least Concern
Caspian Tern	*Hydroprogne caspia*	Vulnerable
Swift Tern	*Sterna bergii*	Least Concern
Roseate Tern	*Sterna dougallii*	Endangered
Damara Tern	*Sterna balaenarum*	Vulnerable

3.3.3.5 Marine Mammals

The marine mammal fauna occurring off the southern African coast includes several species of whales and dolphins and one resident seal species.

Cetaceans (whales and dolphins)

Thirty fourspecies of whales and dolphins are known (based on historic sightings or strandings records) or likely (based on habitat projections of known species parameters) to occur in these waters (Table 3-2). Current information on the distribution, population sizes and trends of most cetacean species occurring on the west coast of southern Africa is lacking and the precautionary principal must be used when considering possible encounters with cetaceans in this area.

Records from stranded specimens show that the area between St Helena Bay (~32° S, 18° E) and Cape Agulhas (~34° S, 20° E) is an area of transition between Atlantic and Indian Ocean species, as well as those more commonly associated with colder waters of the west coast (e.g. dusky dolphins and long finned pilot whales) and those of the warmer east coast (e.g. striped and Risso’s dolphins) (Findlay *et al.* 1992). The project area lies north of this transition zone and can be considered to be truly on the ‘west coast’.

The distribution of cetaceans can largely be split into those associated with the continental shelf and those that occur in deep, oceanic water. Cetacean density on the continental shelf is usually higher than in pelagic waters as species associated with the pelagic environment tend to be wide ranging across 1,000s of km. As the project area is located on the coast, cetacean diversity in likely to be lower than further offshore on the shelf.

Cetaceans are comprised of two taxonomic groups, the mysticetes (filter feeders with baleen) and the odontocetes (predatory whales and dolphins with teeth). Due to differences in sociality, communication abilities, ranging behavior and acoustic behavior, these two groups are considered separately.A review of the distribution and seasonality of the key cetacean species likely to be found within the project area is provided below.

Table 3-2 lists the cetaceans likely to be found within the project area, based on data sourced from: Findlay *et al.* (1992), Best (2007), Weir (2011) and unpublished records held by the Namibian Dolphin Project. Of the 16 species listed, two areendangered (IUCN Red Data list Categories). The majority of data available on the seasonality anddistribution of large whales in the project area is the result of commercial whaling activities mostly dating from the 1960s. Changes in the timing and distribution of migration may have occurred since these data were collected due to extirpation of populations or behaviours (e.g. migration routes may be learnt behaviours). The large whale species for which there are current data available from the continental shelf waters are the humpback and southern right whale.

Mysticete (Baleen) whales

The majority of mysticetes whales fall into the family Balaenopeteridae. Those occurring in the area include the fin, sei, Antarctic minke, dwarf minke, humpback and Bryde's whales. The southern right whale (Family Balaenidae) and pygmy right whale (Family Neobalaenidae) are from taxonomically separate groups. The majority of mysticete species occur in pelagic waters with only occasional visits to shelf waters. Most of these species show some degree of migration either to or through the latitudes encompassed by the broader project area when *en route* between higher latitude (Antarctic or Subantarctic) feeding grounds and lower latitude breeding grounds. Depending on the ultimate location of these feeding and breeding grounds, seasonality may be either unimodal, usually in winter months, or bimodal (e.g. May to July and October to November), reflecting a northward and southward migration through the area. Northward and southward migrations may take place at different distances from the coast due to whales following geographic or oceanographic features, thereby influencing the seasonality of occurrence at different locations. Because of the complexities of the migration patterns, each species is discussed separately below.

Two genetically and morphologically distinct populations of Bryde's whales (Figure 3-21, left) live off the coast of southern Africa (Best 2001; Penry 2010). The "offshore population" lives beyond the shelf (>200 m depth) off west Africa and is unlikely to be seen in the project area. The "inshore population" of Bryde's, which lives on the continental shelf and Agulhas Bank, is unique amongst baleen whales in the region by being non-migratory. It may move further north into the Benguela current areas of the west of coast of South Africa and Namibia, especially in the winter months (Best 2007).

Sei whales migrate through South African waters, where they were historically hunted in relatively high numbers, to unknown breeding grounds further north. Their migration pattern thus shows a bimodal peak with numbers west of Cape Columbine highest in May and June, and again in August, September and October. All whales were caught in waters deeper than 200m with most caught deeper than 1,000m (Best & Lockyer 2002). There is no current information on abundance or distribution patterns in the region.Sei whales are unlikely to be sighted near the project area due to their distribution further offshore.

Table 3-2: Cetaceans occurrence off the West Coast of South Africa, their seasonality, likely encounter frequency with offshore mining operationsand IUCN conservation status.

Common Name	Species	Seasonality	IUCN Conservation Status
Delphinids			
Dusky dolphin	*Lagenorhynchus obscurus*	Year round	Data Deficient
Heaviside's dolphin	*Cephalorhynchus heavisidii*	Year round	Least Concern
Common bottlenose dolphin	*Tursiops truncatus*	Year round	Least Concern
Common (short beaked) dolphin	*Delphinus delphis*	Year round	Least Concern
Southern right whale dolphin	*Lissodelphis peronii*	Year round	Least Concern
Killer whale	*Orcinus orca*	Year round	Least Concern
False killer whale	*Pseudorca crassidens*	Year round	Least Concern
Baleen whales			
Antarctic Minke	*Balaenoptera bonaerensis*	Winter	Least Concern
Dwarf minke	*B. acutorostrata*	Year round	Least Concern
Fin whale	*B. physalus*	MJJ & ON, rarely in summer	Endangered
Sei whale	*B. borealis*	MJ & ASO	Endangered
Bryde's (offshore)	*B. brydei*	Summer (JF)	Data Deficient
Bryde's (inshore)	*B brydei (subspp)*	Year round	Vulnerable
Pygmy right	*Caperea marginata*	Year round	Least Concern
Humpback	*Megaptera novaeangliae*	Year round, higher in SONDJF	Least Concern
Humpback B2 population	*Megaptera novaeangliae*	Spring Summer peak ONDJF	Vulnerable
Southern right	*Eubalaena australis*	Year round, higher in SONDJF	Least Concern

Figure 3-21: The Bryde's whale *Balaenoptera brydei* (left) and the Minke whale *Balaenoptera bonaerensis* (right) (Photos: www.dailymail.co.uk; www.marinebio.org).

Fin whales were historically caught off the West Coast of South Africa, with a bimodal peak in the catch data suggesting animals were migrating further north during May-June to breed, before returning during August-October *en route* to Antarctic feeding grounds. Some juvenile animals may feed year round in deeper waters off the shelf (Best 2007). There are no recent data on abundance or distribution of fin whales off western South Africa.There are no recent data on the abundance or distribution of fin whales off the west coast, although a sighting in St Helena Bay in 2011 (Mammal Research Institute, unpubl. data) and several sightings in southern Namibia in 2014 and 2015 as well as a number of strandings and acoustic detections (Thomisch *et al.* 2016) in Namibia, confirm their contemporary occurrence in the region.

Two forms of minke whale (Figure 3-21, right) occur in the southern Hemisphere, the Antarctic minke whale (*Balaenoptera bonaerensis*) and the dwarf minke whale (*B. acutorostrata* subsp.); both species occur in the Benguela (Best 2007). Antarctic minke whales range from the pack ice of Antarctica to tropical waters and are usually seen more than ~50 km offshore. Although adults migrate from the Southern Ocean (summer) to tropical/temperate waters (winter) to breed, some animals, especially juveniles, are known to stay in tropical/temperate waters year round. The dwarf minke whale has a more temperate distribution than the Antarctic minke and they do not range further south than 60-65°S. Dwarf minkes have a similar migration pattern to Antarctic minkes with at least some animals migrating to the Southern Ocean during summer. Dwarf minke whales occur closer to shore than Antarctic minkes. Both species are generally solitary and densities are likely to be low in the project area.

The most abundant baleen whales in the Benguela are southern right whales and humpback whales (Figure 3-22). In the last decade, both species have been increasingly observed to remain on the west coast of South Africa well after the 'traditional' South African whale season (June – November) into spring and early summer (October – February) where they have been observed feeding in upwelling zones, especially off Saldanha and St Helena Bay(Barendse*et al.* 2011; Mate*et al.* 2011).

The majority of humpback whales passing through the Benguela are migrating to breeding grounds off tropical west Africa, between Angola and the Gulf of Guinea (Rosenbaum*et al.* 2009; Barendse*et al.* 2010). Those breeding in this area are defined as Breeding Stock B1 (BSB1) by the International Whaling Commission (IWC), and were estimated at 9,000 individuals in 2005 (IWC 2012). Animals feeding in the southern Benguela are defined as population BSB2 by the IWC and are genetically distinct from BSB1, although there are resightings of individuals between the areas and it remains unclear exactly how animals in BSB1 and BSB2 relate to each other. BSB2 was estimated as only 500 individuals in 2001-2002 (Barendse *et al.* 2011) and both populations have increased since this time at least 5 % per annum (IWC 2012). Humpback whales in the SE Atlantic migrate north during early winter (June), meet and then follow the coast at varying places, so there is no clear migration 'corridor' on the west coast of South Africa. On the southward migration, returning from tropical West Africa, many humpbacks follow the Walvis Ridge offshore after leaving Angola then head directly to high latitude feeding grounds, while others follow a more coastal route (including the majority of mother-calf pairs), lingering in the feeding grounds off west South Africa in summer (Elwen *et al.* 2014; Rosenbaum *et al.* in 2014, Findlay *et al.* 2017). The number of humpback whales feeding in the southern Benguela has increased substantially since estimates made in the early 2000s (Barendse *et al.* 2011). Since ~2011, 'supergroups' of up to 200 individual whales have been observed feeding within 10 km from shore (Findlay *et al.*2017) with many hundred more passing through and whales are now seen in all months of the year around Cape Town. In the first half of 2017 (when numbers are expected to be at their lowest) more than 10 humpback whales were reported stranded along the Namibian and west South African coasts. The cause of these deaths is not known, but a similar event off Brazil in 2010 was linked to possible infectious disease or malnutrition (Siciliano *et al*. 2013), which suggests the West African population may be undergoing similar stresses and caution should be taken in increasing stress through human activities. Humpback whales are thus likely to be the most frequently encountered baleen whale in the offshore portions of the concession areas with year-round presence but numbers peaking in July for the northwards migration and October to February during the southward migration and when animals from the BSB2 population are feeding in the Benguela Ecosystem.

Figure 3-22: The Humpback whale *Megaptera novaeangliae* (left) and the Southern Right whale *Eubalaena australis* (right) are the most abundant large cetaceans occurring along the southern African West Coast (Photos: www.divephotoguide.com; www.aad.gov.au).

The southern African population of southern right whales historically extended from southern Mozambique (Maputo Bay) to southern Angola (Baie dos Tigres) and is considered to be a single population within this range (Roux *et al*. 2011). While in southern African waters, the vast majority of whales remain with a few kilometers of shore, predominantly in sheltered bays. The most recent abundance estimate for this population (2017), estimated the population at ~6,116 individuals including all age and sex classes, which is thought to be at least 30% of the original population size with the population growing at ~6.5% per year since monitoring began (Brandaõ *et al*. 2018). Although the population is likely to have continued growing at this rate overall, there have been observations of major changes in the numbers of different classes of right whales seen; notably there has been a significant decrease in the number of adults without calves seen in near-shore waters since 2009 (Roux *et al*. 2015; Vinding *et al*. 2015). A large resurgence in numbers of right whales along the SA coast in 2018 and analysis of calving intervals suggests that these 'missing whales' are largely a result of many animals shifting from a 3 year to 4 year calving intervals (Brandaõ*et al*. 2018). The reasons for this are not yet clear but may be related to broadscale shifts in prey availability in the Southern Ocean, as there has been a large El Nino during some of this period. Importantly, many right whales also feed in summer months in the Southern Benguela, notably St Helena Bay (Mate *et al*. 2011). Several animals fitted with satellite tags which fed in St Helena Bay took an almost directly south-west path from there when leaving the coast. There are no current data available on the numbers of right whales feeding in the St Helena Bay area but mark-recapture data from 2003-2007 estimated roughly one third of the South African right whale population at that time were using St Helena Bay for feeding (Peters *et al.* 2005). Pelagic concentrations of right whales were recorded in historic whaling records, in a band between 30°S and 40°S between Cape Town and Tristan da Cunha (Best 2007), well offshore of the concession areas. These aggregations may be a result of animals feeding in this band, or those migrating south west from the Cape. Given this high proportion of the population known to feed in the southern Benguela, and the historical records, it is highly likely that large numbers of right whales may pass through the concession areas between November and January.

Odontocetes (toothed) whales

The Odontoceti are a varied group of animals including the dolphins, porpoises, beaked whales and sperm whales.

Killer whales have a circum-global distribution being found in all oceans from the equator to the ice edge (Best 2007). Killer whales occur year round in low densities off western South Africa (Best *et al.* 2010), Namibia (Elwen & Leeney 2011) and in the Eastern Tropical Atlantic (Weir *et al.*2010). Killer whales are found in all depths from the coast to deep open ocean environments and may thus be encountered in the project area at low levels.

The false killer whale has a tropical to temperate distribution and most sightings off southern Africa have occurred in water deeper than 1,000 m, but with a few recorded close to shore (Findlay *et al.* 1992). They usually occur in groups ranging in size from 1-100 animals (Best 2007). The strong bonds and matrilineal social structure of this species makes it vulnerable to mass stranding (8 instances of 4 or more animals stranding together have occurred in the western Cape, all between St Helena Bay and Cape Agulhas). There is no information on population numbers or conservation status and no evidence of seasonality in the region (Best 2007).

The common dolphin is known to occur offshore in West Coast waters (Findlay *et al.* 1992; Best 2007), although the extent to which they occur in the project area is unknown, but likely to be low. Group sizes of common dolphins can be large, averaging 267 (± *SD* 287) for the South Africa region (Findlay*et al.* 1992). They are more frequently seen in the warmer waters offshore and to the north of the country, seasonality is not known.

In water <500m deep, dusky dolphins (Figure 3-23, right) are likely to be the most frequently encountered small cetacean as they are very "boat friendly" and often approach vessels to bowride. The species is resident year round throughout the Benguela ecosystem in waters from the coast to at least 2,000 m deep (Findlay *et al.* 1992). Although no information is available on the size of the population, they are regularly encountered in near shore waters between Cape Town and Lamberts Bay (Elwen*et al.*2010a; NDP unpubl. data) with group sizes of up to 800 having been reported (Findlay*et al.* 1992). A hiatus in sightings (or low density area) is reported between ~27°S and 30°S, associated with the Lüderitz upwelling cell (Findlay *et al.* 1992). Dusky dolphins are resident year round in the Benguela.

Heaviside's dolphins (Figure 3-23, left) are relatively abundant in the Benguela ecosystem region with 10,000 animals estimated to live in the 400 km of coast between Cape Town and Lamberts Bay (Elwen *et al.* 2009). This species occupies waters from the coast to at least 200 m depth, (Elwen*et al.* 2006; Best 2007), and may show a diurnal onshore-offshore movement pattern (Elwen *et al.* 2010b), but this varies throughout the species range.

Heaviside's dolphins are resident year roundand likely to be frequently encountered off the project area.

Figure 3-23: The endemic Heaviside's Dolphin *Cephalorhynchus heavisidii* (left) (Photo: De Beers Marine Namibia), and Dusky dolphin*Lagenorhynchus obscurus* (right) (Photo: scottelowitzphotography.com).

All whales and dolphins are given protection under the South African Law. The Marine Living Resources Act, 1998 (No. 18 of 1998) states that no whales or dolphins may be harassed, killed or fished. No vessel or aircraft may, without a permit or exemption, approach closer than 300 m to any whale and a vessel should move to a minimum distance of 300 m from any whales if a whale surfaces closer than 300 m from a vessel or aircraft.

Seals

The Cape fur seal (*Arctocephalus pusillus pusillus*) (Figure 3-24) is the only species of seal resident along the west coast of Africa, occurring at numerous breeding and non-breeding sites on the mainland and on nearshore islands and reefs (see Figure 3-25). Vagrant records from four other species of seal more usually associated with the subantarctic environment have also been recorded: southern elephant (*Mirounga leoninas),* subantarctic fur (*Arctocephalus tropicalis),* crabeater *(Lobodon carcinophagus)* and leopard seals (*Hydrurga leptonyx)* (David 1989).

There are a number of Cape fur seal colonies within the broader study area: at Kleinzee (incorporating Robeiland), at Bucchu Twins near Alexander Bay, and Strandfontein Point (south of Hondeklipbaai). The colony at Kleinzee has the highest seal population and produces the highest seal pup numbers on the South African Coast (Wickens 1994). The colony at Buchu Twins, formerly a non-breeding colony, has also attained breeding status (M. Meyer, DAFF, pers. comm.). Non-breeding colonies occur south of Hondeklip Bay at Strandfontein Point and on Bird Island at Lamberts Bay, with the McDougall's Bay islands and Wedge Point being haul-out sites only and not permanently occupied by seals. All have important conservation value since they are largely undisturbed at present. Seals are highly mobile animals with a general foraging area covering the continental shelf up to 120 nautical miles offshore (Shaughnessy 1979), with bulls ranging further out to sea than females. The timing of the annual breeding cycle is very regular, occurring between November and January. Breeding success is highly dependent on the local abundance of food, territorial bulls and lactating females being most vulnerable to local fluctuations as they feed in the vicinity of the colonies prior to and after the pupping season (Oosthuizen 1991).

Figure 3-24: Colony of Cape fur seals *Arctocephalus pusillus pusillus* (Photo: Dirk Heinrich).

3.4. Other Uses of the Area

3.4.1 Beneficial Uses

The proposed mining area extends from the high water mark to the edge of the surf zone atapproximately -5 m depth. Other users of these areas include Alexkor's marine diamond mining contractors, the commercial and recreational fishing industries anda kelp collection concession.

3.4.1.1 Diamond Mining

The coastal mining licence areasextend some distance inland, and as a consequence public access to the coast is restricted, and recreational activities between Alexander Bay and Hondeklipbaai is limited to the area around Port Nolloth and McDougall's Bay.

The marine diamond mining concession areas are split into four or five zones (Surf zone and (a) to (c) or (d)-concessions), which together extend from the high water mark out to approximately 500 m depth. Shore-based and vessel-based diver-assisted mining is restricted to Alexkor's contractors.

3.4.1.2Kelp Collecting

The West Coast is divided into numerous seaweed concession areas. The Whale Head Minerals project area falls within seaweed concession 19 held by Premier Fishing, which extends from just north of Port Nolloth to the Orange River mouth. Access to a seaweed concession is granted by means of a permit from the Fisheries Branch of the Department of Agriculture, Forestry and Fisheries to a single party for a period of five years. The seaweed industry was initially based on sun dried beach-cast seaweed, with harvesting of fresh seaweed occurring in small quantities only (Anderson *et al.* 1989). The actual level of beach-cast kelp collection varies substantially through the year, being dependent on storm action to loosen kelp from subtidal reefs (Table 3-3). Permit holders collect beach casts of the both *Ecklonia maxima* and

Laminaria pallida from the driftline of beaches. The kelp is initially dried just above the high water mark before being transported to drying beds in the foreland dune area. The dried product is ground before being exported for production of alginic acid (alginate). In the areas around abalone hatcheries fresh beach-cast kelp is also collected as food for cultured abalone, although quantities have not been reported to the Department of Agriculture, Forestry and Fisheries (DAFF). There has been no activity in kelp concession 19 over the past decade.

Table 3-3: Beach-cast collections (in kg dry weight) for kelp concessions north of Lamberts Bay (Data source: Seaweed Section, DAFF).

	Concession Number					
	13	14	15	16	18	19
Concession Holder	Eckloweed Industries	Eckloweed Industries	Rekaofela Kelp	Rekaofela Kelp	FAMDA	Premier Fishing
2005	65,898	165,179	10,300	35,920	0	0
2006	94,914	145,670	19,550	28,600	0	0
2007	122,095	79,771	0	84,445	0	0
2008	61,949	204,365	23,646	16,804	0	0
2009	102,925	117,136	0	0	0	0
2010	53,927	166,106	0	0	0	0
2011	40,511	72,829	0	0	0	0
2012	43,297	151,561	160,500	156,000	0	0
2013	20,485	97,283	36,380	24,000	0	0
2014	19,335	136,266	74,300	75,743	0	0
2015	52,827	158,184	0	0	0	0
2016	69,363	154,010	0	0	0	0

3.4.1.3Rock Lobster Fishery

The West Coast rock lobster *Jasus lalandii* is a valuable resource of the South African West Coast and consequently an important income source for West Coast fishermen. Following the collapse of the rock-lobster resource in the early 1990s, fishing has been controlled by a Total Allowable Catch (TAC), a minimum size, restricted gear, a closed season and closed areas (Crawford *et al*. 1987, Melville-Smith *et al*. 1995). The fishery is divided into the offshore fishery (30 m to 100 m depth) and the near-shore fishery (< 30 m depth), thereby overlapping with the mining licence areas. Management of the resource is geographically specific, with the TAC annually allocated by Area. The Whale Head Minerals target areafalls within Management Area 1 of the commercial rock lobster fishing zones, which extends from the Orange River Mouth to Kleinzee. The fishery operates seasonally, with closed seasons applicable to different zones; Management Areas 1 and 2 operate from 1 October to 30 April.

Commercial catches of rock lobster in Area 1 are confined to shallower water (<30 m) with almost all the catch being taken in <15 m depth, therefore overlapping directly with diver-assisted vessel-based mining operations. Actual rock-lobster fishing, however, takes place only at discrete suitable reef areas along the shore within this broad depth zone. Lobster fishing is conducted from a fleet of small dinghies/bakkies. The majority of these work directly from the shore within a few nautical miles of the harbours, with only 30% of the total numbers of bakkies partaking in the fishery being deployed from larger deck boats. As a result, lobster fishing tends to be concentrated close to the shore within a few nautical miles of Port Nolloth and Hondeklip Bay. Landings of rock lobster recorded within Area 1 have been reported at an average total rock lobster tail weight of 16 tons per year (2008 – 2012). All landings were reported by bakkies, with no landings made by the offshore sector. This amounts to 0.8% of the total landings recorded by the West Coast rock lobster fishery (inclusive of both the near-shore and offshore fisheries) and 4.1% of the total landings recorded by the bakkie fleet.

Rock lobster landings from Area 1 and 2 for the years 2006 to 2017are provided in

Table 3-4. Catches for Area 2, which extends from Kleinzee to the mouth of the Brak River, are provided for comparison.

Table 3-4: Total Allowable Catch (TAC) and Actual landed catch (kgs) for Areas 1 and 2 in the Northern Cape during the 2005/06 to 2016/2017 fishing seasons (Data source: Rock Lobster Section, DAFF).

Year	TAC	Area1	Area 2
2006	30,000	27,595	40
2007	30,000	14,983	1,487
2008	30,000	21,901	1,764
2009	24,000	20,891	1,345
2010	24,000	15,482	2,089
2011	24,000	8,223	1,406
2012	24,000	4,680	801
2013	24,000	6,242	0
2014	24,000	8,960	541
2015	20,000	3,163	961
2016	24,000	6,201	717
2017	24,000	2,966	119

3.4.1.4Recreational Fisheries

Recreational and subsistence fishing on the West Coast is small in scale when compared with the south and east coasts of South Africa. The population density in Namaqualand is low, and poor road infrastructure and ownership of much of the land by diamond companies in the northern parts of the West Coast has historically restricted coastal access to the towns and recreational areas of Port Nolloth, McDougall’s Bay, Hondeklipbaai and the Groenrivier mouth.

Recreational line-fishing is confined largely to rock and surf angling in places such as Brand-se-Baai, well to the south of the mining licence areas, and the more accessible coastal stretches in the regions. Boat angling is not common along this section of the coast due to the lack of suitable launch sites and the exposed nature of the coastline. Fishing effort has been estimated at 0.12 angler/km north of Doringbaai. These fishers expended effort of approximately 200,000 angler days/year with a catch-per-unit-effort of 0.94 fish/angler/day (Brouwer *et al*. 1997; Sauer & Erasmus 1997). Traget species consist mostly of hottentot, white stumpnose, kob, steenbras and galjoen, with catches being used for domestic consumption, or are sold.

Recreational rock lobster catches are made primarily by diving or shore-based fishing using baitbags. Hoop-netting for rock lobster from either outboard or rowing boats is not common along this section of the coast (Cockcroft & McKenzie 1997). Most of the recreational catch is made early in the season, with 60% of the annual catch landed by the end of January. The majority of the recreational take of rock lobster (~68%) is made by locals resident in areas close to the resource. Due to the remoteness of the area and the lack of policing, poaching of rock lobsters by the locals,seasonal visitors as well as the shore-based mining units is becoming an increasing problem. Large numbers of rock lobsters are harvested in sheltered bays along the Namaqualand coastline by recreational divers who disregard bag-limits, size-limits or closed seasons. This potentially has serious consequences for the sustainability of the stock in the area.

3.4.1.5 Mariculture

Although the Northern Cape coast lies beyond the northern-most distribution limit of abalone (*Haliotis midae*) on the West Coast, ranching experiments have been undertaken in the region since 1995(Sweijd *et al*. 1998, de Waal & Cook 2001, de Waal 2004). As some sites have shown high survival of seeded juveniles, the Department of Agriculture, Forestry and Fisheries (DAFF) published criteria for allocating rights to engage in abalone ranching or stock enhancement (Government Gazette No. 33470, Schedule 2, 20 August 2010) in four areas along the Namaqualand Coast (

Table 3-5). Ranching in these areas iscurrently being investigated at the pilot phase. The Whale Head Minerals target area falls within area NC1 held by Turnover Trading. No seeding has as yet commenced in the area and the Department of Agriculture, Forestry and Fisheries are still awaiting the baseline assessment for the area (I. Zimasa Jika, DAFF, pers. comm., March 2020)

Associated with the ranching projects are land-based abalone hatcheries located at North Point near Port Nolloth, at Kleinzee and at Hondeklipbaai. These hatcheries operate on a semi-recirculation system using seawater pumped from the shallow subtidal zone to top-up the holding tanks (Anchor Environmental Consultants 2010).

Table 3-5: Allocated abalone ranching areas in the Northern Cape.

Area	Description	Latitude	Longitude	Rights Holder
NC1	Boegoeberg North	28°45’41.35”S	16°33’41.93”E	Turnover Trading
	Beach north of North Point	29°14’07.65”S	16°51’14.08”E	
NC2	South-end of McDougall Bay	29°17’34.23”S	16°52’32.08”E	Really Useful Investments No 72
	Rob Island	29°40’07.12”S	16°59’50.45”E	
NC3	Beach at Kleinzee	29°43’43.09”S	17°03’03.50”E	Port Nolloth Sea Farms
	Swartduine	30°02’52.04”S	17°10’39.69”E	
NC4	Skulpfontein	30°06’08.15”S	17°11’08.03”E	Diamond Coast Abalone
	2 rocks 200 m from shore	30°25’56.26”S	17°20’05.43”E	

3.4.2 Conservation Areas and Marine Protected Areas

The only conservation area along the Northern Cape coast in which restrictions apply is the McDougall's Bay rock lobster sanctuary near Port Nolloth, which is closed to exploitation of rock lobsters (Figure 3-25). The sanctuary, which extends one nautical mile seawards of the high water mark betweenthe promontory at the northern end of McDougall's Bay, and the promontory at the southern extremity of McDougall's Bay, lies well south of the mining target area.

Using biodiversity data mapped for the 2004 and 2011 National Biodiversity Assessments a systematic biodiversity plan was developed for the West Coast with the objective of identifying coastal and offshore priority focus areas for MPA expansion (Sink *et al.* 2011; Majiedt *et al.* 2013).Potentially vulnerable marine ecosystems (VMEs) that were explicitly considered during the planning included the shelf break, seamounts, submarine canyons, hard grounds, submarine banks, deep reefs and cold water coral reefs.The biodiversity data were used to identify ten focus areas for protection on the West Coast between Cape Agulhas and the South African – Namibian border. These focus areas were carried forward during Operation Phakisa, which identified potential MPAs. Those approved MPAs within the broad project area are shown in Figure 3-25. The proposed project area does not fall within any of these MPAs, or with any other coastal MPAs, sanctuaries or conservation areas.

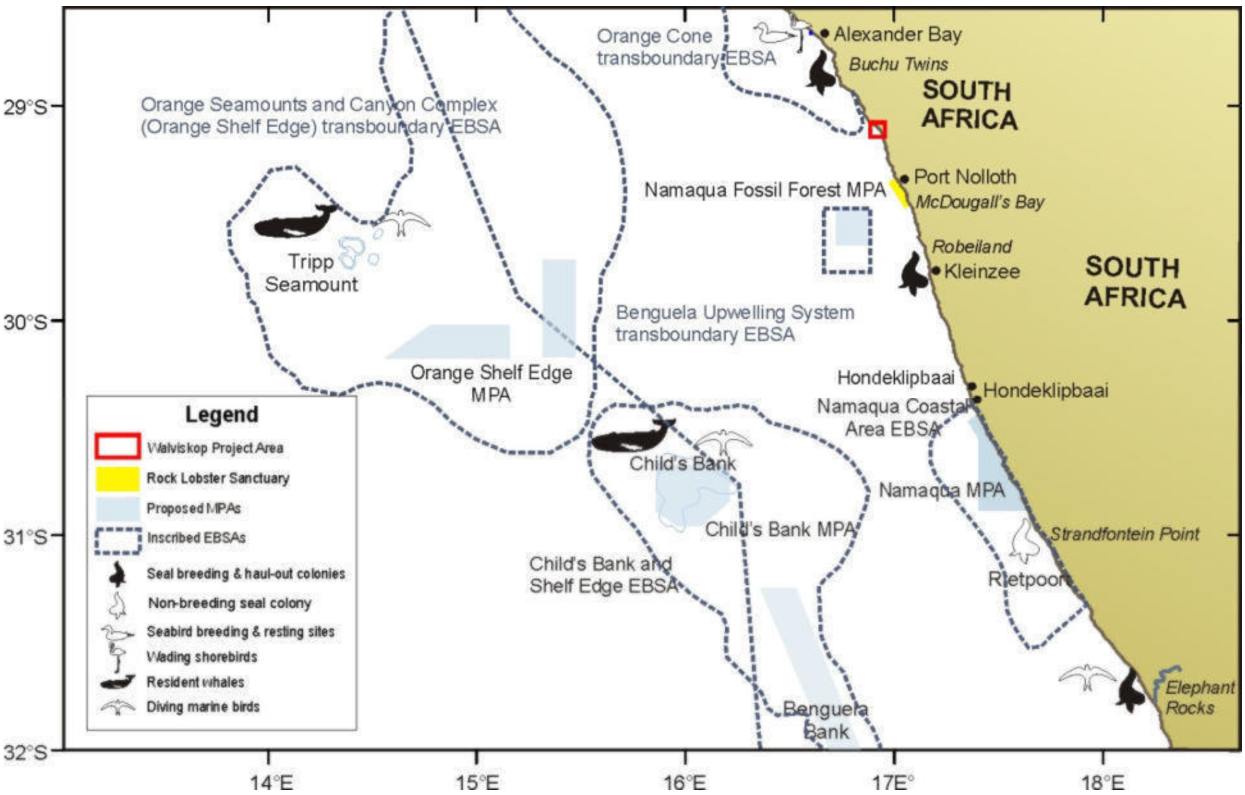


Figure 3-25: Project - environment interaction points on the West Coast, illustrating the location of seabird and seal colonies and resident whale populations in relation tothe Project Area (red square).Offshore Marine Protected Areas and EBSAs (as of 27 March 2020) are also shown.

As part of a regional Marine Spatial Management and Governance Programme (MARISMA; 2014-2020) the Benguela Current Commission (BCC) and its member states have identified a number of Ecologically or Biologically Significant Areas (EBSAs) both spanning the border between Namibia and South Africa and along the South African West and South Coasts, with the intention of implementing improved conservation and protection measures within these sites. Those areas identified as being of high priority for place-based conservation measures within the broad project area are shown in Figure 3-25. These EBSAs have been proposed and inscribed under the Convention of Biological Diversity (CBD). There is no overlap with the proposed project area and any of these EBSAs.

The principal objective of these EBSAs is identification of features of higher ecological value that may require enhanced conservation and management measures. No specific management actions have been formulated for the various areas at this stage.

3.4.3Threat Status and Vulnerable Marine Ecosystems

Until early 2019, 'no-take' MPAs offering protection of the Namaqua biozones (sub-photic, deep-photic, shallow-photic, intertidal and supratidal zones) were absent northwards of Cape Columbine (Emanuel *et al*. 1992; Lombard *et al*. 2004). Rocky shore and sandy beach habitats are generally not particularly sensitive to disturbance and natural recovery occurs within 2-5 years. However, much of the Namaqualand coastline has been subjected to decades of disturbance by shore-based diamond mining operations (Penney *et al*. 2007). These cumulative impacts and the lack of biodiversity protection has resulted in the coastal habitat types in Namaqualand beingassigned a threat status of 'endangered', 'vulnerable' or of 'least concern' (Sink *et al*. 2019). Using the SANBI benthic and coastal habitat type GIS database, the threat status of the benthic habitats in the general area, and those potentially affected by proposed heavy mineral sands mining at Walviskop, were identified (Table 3-6; see also Figure 3-11). The proposed mining area falls within the Namaqua Mixed Shore habitat type, which is considered 'vulnerable'.

Table 3-6: Ecosystem threat status for marine and coastal habitat types in the broader project area of Whale Head Minerals proposed mining area (adapted from Sink *et al*. 2019). Those habitats potentially affected by the proposed mining activities are shaded.

Habitat Type	Total Size (km^2)	Threat Status
Namaqua Exposed Rocky Coast	42.49	Vulnerable
Namaqua Mixed Shore	60.66	Vulnerable
Namaqua Very Exposed Rocky Coast	3.15	Vulnerable
Namaqua Kelp Forest	7.36	Vulnerable
Southern Benguela Dissipative-Intermediate Sandy Coast	51.47	Least Concern
Orange Cone Inner Shelf Mud Reef Mosaic	511.02	Endangered
Orange Cone Muddy Mid Shelf	1 925.36	Endangered

4. IDENTIFICATION AND ASSESSMENT OF IMPACTS OF COASTAL MININGON MARINE FAUNA

This chapter describes and assesses the significance of potential direct and indiract impacts related to the proposed heavy mineralsmining activities in the Walviskop area. All impacts are assessed according to the rating scale defined in Section 1.2.2. Where appropriate, mitigation measures are proposed, which could ameliorate the negative impacts or enhance potential benefits, respectively. The significance of impacts with and without mitigation is assessed.

For the marine component, the following phases of the project were taken into consideration in the overall impact assessment:

- **Construction Phase**: impacts associated with the actual construction activities on the beach, including the placing of equipment and pipelines.
- **Operational Phase / Commissioning**: activities related to the mining and processing of sediments and the discard of tailings.
- **Decommissioning**: activities that relate to rehabilitation of the beach area after mining has ceased. This includes backfilling of mining voids, levelling of tailings mounds and removal of equipment and pipelines.

For the current project, however, these phases will not be independent, as unfavourable weather may require rapid removal of equipment and pipelines off the beach, with subsequent re-installation once conditions improve. Moreover, in the wave-influenced intertidal and shallow subtidal zones natural backfilling of mining voids will occur during each tidal cycle and concurrently to mining. To avoid repetition, the impacts are thus not discussed under separated headings.

4.1. Identification of Impacts

Beaches are highly attractive to a wide variety of human use, ranging from recreational pedestrian traffic, through large-scale beachfront developments to intensive seawall mining as practiced in southern Namibia. All of these activities, as well as storm events and other natural processes, can alter the physical characteristics of the beaches resulting in temporary or permanent alterations in faunal communities inhabiting them (McLachlan *et al*. 1994; Defeo & Alava 1995; Alonso *et al*. 2002; Borges *et al*. 2002; Brown & McLachlan 2002; Gomez-Pina *et al*. 2002). Such changes may alter the manner in which beaches function as an interface between the marine and terrestrial environments, either in terms of their physical behaviour or their role in nutrient cycling. The magnitude of the impact depends on an interactive balance between the relative sensitivity of particular beaches to physical disturbance and the degree of anthropogenic disturbance imposed.

The most sensitive part of the littoral active zone is the fore-dune area, which is the beach/dune interface (Brown & McLachlan 2002). Fore or primary dunes (the small sparsely vegetated dunes just above the drift line), as well as the stabilised, large secondary dunes, are a transition zone between the physically and biologically different terrestrial habitats, and surf-zone processes. As this specialist report focuses on the intertidal beach area below the high water mark, the dune/cliff area falls outside of the scope of this study.

Certain beaches are comparatively sheltered and naturally undisturbed, and their faunal communities are typically sensitive to anthropogenic physical disturbance. In contrast, other beaches are exposed to substantial natural environmental disturbance (wind, wave and tidal impacts), and they and their faunal communities are robust to such disturbance (Brown & McLachlan 2002). Sandy beaches facing open oceans are highly dynamic and their associated faunal communities naturally variable, particularly over short to medium time frames (tidal cycles, storm events, seasons or inter-annual weather changes) (McLachlan 1980; Souza & Gianuca 1994; Calliari *et al*. 1996). On such dynamic beaches, it is often difficult to identify trends in beach faunal community structure over and above natural variation, particularly those due to anthropogenic disturbance.

A number of environmental issues of concern have been raised around the mining of coastal heavy mineral deposits both in South Africa (Biccard *et al*. 2018) and in other parts of the world (Saravanan & Chandrasekar 2010; Chandrasekar *et al*. 2014; Van Gosen et al 2014; Sengupta & Ghosal 2017). These include:

- alteration of coastal topographical features;
- effects on hydrogeology, particularly the depth to the water table;
- effects on indigenous flora and fauna species due to vegetation removal in habitat and wildlife corridors, respectively;
- fragmentation of habitats and alteration of ecological processes;
- crushing and trampling of flora and fauna by heavy vehicle traffic, excavation of sands and stockpiling of plantfeed, tailings and/or concentrate;
- effects on soil biota and the seedbank through topsoil stripping;
- effects of tailings disposal onto beaches, into estuaries or wetlands or into mining voids;
- increased turbidity in rivers, estuaries and the marine environment through ersoion of sediments in the mining area;
- effects of noise and light pollution, dust, increased heavy transport traffic, disruption of and increased burden on the local infrastructure, air quality; and
- spread of alien invasive species.

Many of these environmental issues, however, apply primarily to large-scale operations such as Richard's Bay Minerals, Tormin and Namakwa Sands and are not relevant to a much smaller-scale, localised operation usch as that proposed by Whale Head Minerals.

Nonetheless, the proposed mining of heavy mineral sands at Walviskop may potentially result in a number of direct and indirect impacts on the marine biota of the beach itself, as well as those in adjacent marine habitats. More specifically, these include:

- Disturbance and alteration of supratidal habitats and loss of associated dune and coastal vegetation and biota throughcrushing and compacting by vehicles and heavy equipment,trampling by personnel and loss of terrestrial resources through illegal plant collection;
- Crushing of invertebrate beach macrofauna through heavy vehicle traffic, plant infrastructure and pipelines;
- Disturbance or loss of invertebrate beach macrofauna through excavation and processing of sands;
- Changes in the sediment particle size distribution on the beach with concomitant changes in beach profile and morphodynamic state;
- Changes in invertebrate macrofaunal community composition in response to physical

changes in the beach;
- Smothering of invertebrate beach macrofauna as a consequence of tailings discharges;
- Increased turbidity in the surf-zone opposite the mining site through suspension of sediments and overspill of processing runoff water with potential effects on phytoplankton production and foraging efficiency of higher order consumers;
- Potential indirect impacts on adjacent rocky shores through mobilisation and re-deposition of sediments;
- Habitat deterioration through littering, pollution and accidental spills; and
- Effects on other users of the marine environment as a result of mining operations on the beach.

These potential impacts will be evaluated in the light of information from studies on beach mining conducted in southern Namibia, and on the Namaqualand and Western Cape coasts, and from the scientific literature, andin the context of the short-and long-term natural disturbances characterising the nearshore marine environment in the Benguela region. The potential impacts relate more or less to all three project phases and will thus not be assessed separately here.

4.2. Assessment of Direct Impacts

The impacts of beach mining activities on marine benthic communities have been comprehensively investigated over the past 20 years thereby providing a good understanding of the potential impacts that might be expected from on-going activities. The identified environmental aspects and the related potential impacts are discussed and assessed below using information from the available literature.

4.2.1 Physical disturbance of benthic habitats

By its very nature, the mining of beach sands for the extraction of heavy mineralswill results in the physical disturbance of the shoreline and seabed. The magnitude and extent of the disturbance is, however, dependent both on the location of the target ores and the mining approach.

4.2.1.1 Disturbance and loss of supratidal[1] habitats and associated biota

The project activities that will physically disturb and alter supratidal habitat are described further below.

- Mining contractors operational in the intertidal and surf zones typically establish tracks in the coastal zone to permit access to their mining areas by vehicles, tractors and heavy equipment.
- A processing plant and offices would need to be establishedabove the high water mark to provide on-site facilities.
- Poaching of marine resources and illegal collecting of succulents by mining personnel may occur.
- Following completion of mining operations in an area mining infrastructure and equipment may be left on site, or discarded if the equipment becomes derelict.

[1]The supratidal zone lies above the mean high water spring tide mark and is only occasionally inundated by water during exceptional tides or by tides augmented by storm surges.

The impacts associated with mining activities in the coastal zone all result in severe scarring of the landscape, compaction of surface soils, destabilisation of dunes, disturbance and/or destruction of plant communities, and degradation of faunal communities dependant on the affected vegetation. Any biota present in the footprint of the plant site and high-shore mining area is likely to be crushed and trampled by vehicle activities, equipment and personnel.

The degree of impact associated with access tracks and plant sites depends on the scale of the mining activity and the type of terrain disturbed. Construction of the plant area, infrastructure and access routes will results in localised removal of vegetation, which can potentially lead to soil erosion and removal of topsoil and its associated plant seed bank depending on where the plant, infrastructure and access routes are located. While actively forming soils tend to support rugged pioneer plant communities, which are typically dynamic and resilient to disturbances, older, more stable soils harbour established terrestrial plant communities more sensitive to disturbance of the soil equilibrium. Such plant communities and their dependent fauna usually only recover over the long term following disturbance of the soil equilibrium.The indiscriminate storage of mining equipment and vehicles, the location of treatment plants, stockpiles and vehicle parking areas, and proliferation of informal tracks can also damage vegetation and lead to compaction of soil and uncontained erosion of access roads, thus hampering the re-establishment of vegetation. Where access roads to mining sites traverse dunes, the crushing and destruction of dune vegetation can affect dune stability and dynamics, potentially leading to wind erosion and the creation of blow-outs. The fore-dune area(the small sparsely vegetated dunes just above the drift line) in particular,is the most sensitivepart of the littoral active zone as it serves as a transition zone between the physically and biologically different terrestrial habitats, and surf zone processes (Brown & McLachlan 2002). As such, individual beaches may develop specific characteristics, resulting from local physical conditions, and the resultant faunal and floral communities are adapted to these specific characteristics.

Poaching of wild life and marine resources,and illegal succulent collecting by mining personnel have also been identified as major threats to the coastal flora and fauna (Newton & Chan 1998; Burke & Raimondo 2002). Mining infrastructure and discarded equipment left on site also hinders recovery of the arid terrestrial ecosystems, as well as resulting in severe aesthetic impacts.

Impacts associated with the disturbance of supratidal habitats would be of high intensity, but would remain localised around the Walviskop site. Due to the sensitivity of the coastal habitats to disturbance, impacts would persist over the medium- to long term and be only partially reversible. The likelihood of impacts to coastal vegetation and biota is highly probable and any adverse effects on coastal biota are considered of **HIGH** significance without mitigation and **LOW** significance with mitigation.

Mitigation

The following mitigation measures are proposed:

- Prepare a site- and project-specific Environmental Code of Practice (ECOP) for the Walviskop operation. The ECOP should include specific details for the following aspects:

   - Environmental considerations (i.e. identification of sensitive receptors) and establishment of no-go areas
   - Access route(s) to the allocated beach
   - Extent of mining block and demarcation of the facilities and processing area(s), and refuelling / maintenance areas
   - Housing keeping:
      - Use of drip trays under stationary plant and for refuelling and maintenance activities
      - Use and maintenance of toilet facilities
      - Bunding of fuel stores
      - Demarcation of refuelling and maintenance areas
   - Waste management, including the removalof all facilities, waste and other features established during mining activities
   - Rehabilitation specification (if necessary), e.g. topsoil management, reshaping, netting, etc.
   - Establishment of a rehabilitation fund
   - Monitoring
- Use only established tracks and roads to access the allocated pocket beach in order to avoid the creation of new tracks.
- Identify and map the required existing tracks and develop a maintenance and rehabilitation program that ensures that necessary tracks are maintained. Permitted tracks are to be marked as such and all duplicate tracks leading to mining sites should be closed and rehabilitated.
- Avoid the establishment of processing areas within 100 m of the edge of a river channel or estuary mouth.
- Locate processing areas as far as possible in previously disturbed areas or areas of least sensitivity.
- Limit the processing area and office facilities to the minimum reasonably required and to that which will cause least disturbance to the vegetation and natural environment. The extent of the sites should be clearly demarcated (e.g. with droppers).
- Do not collect any plants within or around the mining area.
- Undertake Environmental Awareness Training to ensure mining personnel are appropriately informed of the purpose and requirements of the EMPr and ECOP.
- Before the commencement of any work on site, the contractor's site staff must attend an environmental awareness-training course presented by Alexkor'sEnvironmental Manager/Officer. The contractor must keep records of all environmental training sessions, including names of attendees, dates of their attendance and the information presented to them.
- Prior to leaving the mining site, the area must be audited by Alexkor'sEnvironmental Manager/Officer. Only once the Environmental Manager/Officer is satisfied that the area has been suitably cleaned and rehabilitated should the rehabilitations funds be paid back to the contractor.

Destruction and loss of coastal vegetation and biota		
	Without Mitigation	**Assuming Mitigation**
Intensity	High	Medium
Duration	Medium- to Long-term	Medium-term
Extent	Local: limited to the Walviskop area	Local
Consequence	High	Low
Probability	Probable	Probable
Significance	High	Low
Status	Negative	Negative
Confidence	High	High

Nature of Cumulative impact	Due to decades of coastal mining in the area cumulative impacts from heavy minerals mining can be expected
Reversibility	Partially reversible
Loss of resources	Medium
Mitigation potential	Low

4.2.1.2 Disturbance and loss of invertebrate macrofauna

The excavators used as the mining tool would primarily be implemented below the high water mark and into the surf zone of the target beach, which is classified as Namaqua Mixed Shore and has been identified as 'vulnerable' (Sink *et al*. 2019). Invertebrate macrofauna living in or on the unconsolidated beach sediments being fluidised and pumped by the excavators would be disturbed, damaged or likely completely eliminated, and those within the footprint of the excavators tracks and under the pipelines would be crushed. Similarly, excavations required for installing the seawater intake would disturb and damage the beach macrofauna in the beach well footprint and crush fauna in the tracks of the excavators. Tailings discarded back onto the beach from the plant would smother invertebrate epifauna and infauna in the intertidal and surf zonesediments (see section 4.2.1.3). Although not directly targeted by the mining tools, the biota associated with the rocky outcrop in the centre of the beach, as well as on the southern and northern extremes of the beach, may be indirectly affected through sediment scouring and smothering following mobilisation and re-deposition of sediments.

While the intertidal area of sandy beaches is characterised by a relatively rich fauna, species abundance typically declines substantially in the surf zone reaching a minimum at the breakpoint of the waves (McLachlan and Brown 2006). Impacts on macrofaunal communities living in the unconsolidated surf zone sediments would thus be comparatively low, particularly as the beach has been previously disturbed by diamond mining operations. Furthermore, the communities inhabiting this naturally highly dynamic environment are inherently robust and habituated to natural disturbances. On a high-energy coastline, such as in the study area,the recovery of the physical characteristics of intertidal and shallow subtidal unconsolidated sediments to their pre-disturbance state following mining by excavatorscan occur within a few tidal cycles under heavy swell conditions, and will typically result in subsequent rapid recovery of the invertebrate epifaunal and infaunal communities to their previous state, provided no severe changes to the sediment structure have occurred.

The benthic communities expected to occur within the project area are largely ubiquitous to the central Benguela region, and no rare or endangered species have been recorded(Awad*et al.* 2002). Furthermore, the beach macrofauna appear to be relatively tolerant to disturbance, and re-colonization of disturbed areas is rapid (van der Merwe & van der Merwe 1991; Brown & Odendaal 1994; Peterson *et al.* 2000; Schoeman *et al.* 2000; Seiderer & Newell 2000; Nel *et al.* 2003). Impacted areas are initially colonized by small, abundant and opportunistic pioneer species with fast breeding responses to tolerable conditions (e.g. crustaceans and polychaetes). Recolonisation of disturbed beaches takes place by passive translocation of animals from adjacent areas during successive tidal cycles or storms, active immigration of mobile species, and immigration and settlement of pelagic larvae and juveniles (Hall 1994; Kenny & Rees 1994, 1996; Herrmann *et al.* 1999; Ellis 2000; Menn 2002). Usually, undisturbed sediments adjacent to the impacted site provide an important source of colonising species, enabling faster recovery (van Moorsel 1993, 1994; Cheshire & Miller 1999).

Due to the intrinsic tolerance of the assemblages inhabiting intertidal beaches, declines in infaunal abundance, biomass, and diversity following disturbances such as small-scale mining, tailings discharges or beach accretion are expected to be short term, with recolonisation following the cessation of disturbance occurring within weeks (Schoeman *et al.* 2000) and recovery of communities to a condition of functional similarity to the original state occurring after 2 to 7 months (Nelson 1985, 1993; Hackney *et al.* 1996). Recovery of macrofaunal diversity and abundance following replenishment of beaches typically occurs within 1 year (Dankers *et al.* 1983; Van Dolah *et al.* 1994; Essink 1997; Jutte *et al.* 1999a, 1999b; USACE 2001; Menn 2002; Menn *et al.* 2003), with full recovery of the benthic community and age structure considered to take between 2 and 5 years (USACE 1989; Kenny & Rees 1994, 1996; Rakocinski *et al.* 1996; Essink 1997; Van Dalfsen & Essink 1997; van Dalfsen *et al.* 2000; Newell *et al.* 2004; Boyd *et al.* 2005; Mulder *et al.* 2005; Baptist *et al.* 2009).In a study investigating the impacts of beach diamond-mining north of the Olifants River, which employed cofferdams constructed of native beach sediments, it was demonstrated that despite a significant immediate negative impact on the biotic parameters studied (abundance, biomass, species richness, and community structure), recovery of macrofaunal communities following the cessation of mining was rapid, with recovery to pre-mining conditions occurring after 20-50 months (Nel *et al.* 2003; Pulfrich *et al.* 2004).

Recovery after repeated disturbance, however, takes longer, particularly if this results in medium- to long-term changes in sediment structure (Menn *et al.* 2003; Janssen & Mulder 2005) (see section 4.2.2).

Impacts associated with the disturbance and loss of intertidal and shallow subtidal macrofaunal communities in unconsolidated habitats by beach mining operations would be of high intensity, but remain relatively localised to each targetted mining block. Impacts to the biota would persist over the short- to medium term and be fully reversible. The likelihood of impacts to intertidal and shallow subtidal biota of unconsolidated sediments by beach mining operations is definite and adverse effects are considered of **MEDIUM** significance without mitigation for operations on sandy beaches. This would reduce to **LOW** significance if all recommended mitigation measures were imposed.

Mitigation

Removal and processing of beach sands are an integral part of the mining approach and other than the 'no-go' option, there is no feasible mitigation for these proposed operations. Disturbance of beach habitat adjacent to the mining blocks can, however, be minimised through stringent environmental management and good house-keeping practices. Active rehabilitation involving backfilling of mined out areas and re-structuring of the mining area to resemble the natural beach morphology should be undertaken concurrently with and on completion of mining operations.

Further recommendations for mitigation include:

- Mine target blocks sequentially from the south to north along the beach, rehabilitating mined-out blocks immediately on cessation of mining in that block;
- Avoid re-mining of blocks, and the target beach as a whole in the medium to long term;
- Designate and actively manage specific access, storage and operations areas;
- Remove all equipment on completion of activities; and
- Flatten all remaining tailings heaps on completion of operations.

Destruction and loss of intertidal and shallow subtidal macrofauna in unconsolidated sediments		
	Without Mitigation	**Assuming Mitigation**
Intensity	High	Medium
Duration	Short- to Medium-term	Short-term
Extent	Local: limited to the Walviskop beach	Local
Consequence	Medium	Very Low
Probability	Probable	Probable
Significance	Medium	Very Low
Status	Negative	Negative
Confidence	High	High

Nature of Cumulative impact	Due to decades of coastal mining in the area cumulative impacts from heavy minerals mining can be expected
Reversibility	Fully reversible
Loss of resources	Medium
Mitigation potential	Low

4.2.1.3 Smothering of benthic biota by discarded tailings

During the mining process, beach sediments are pumped to the plant site located on the shore and discharged onto sorting screens, which separate the large gravel, cobbles and boulders from the 'plantfeed'. Following extraction of the heavy mineral concentrates, the sands are returned to the beach together with the oversize fraction.In the case of the Walviskop operations, the heavy mineral fraction of the sediments is in the 75 – 180 µm range whereas the gangue minerals[2] occur predominantly in the 250 to 500 µm size range. The heavy minerals fraction, which at Walviskop constitutes between 40-50% of the sediments, are separated out, with the remaining 50-60% of the waste material being returned either to the mined-out pits or discarded onto the beach as tailings.The waste stream produced from the wet processing of heavy-mineral sands therefore consists of overburden material, quartz sands and slimes.

If discharged into mine-out areas, the tailings would be returned to a severely disturbed area, which would likely be largely devoid of invertebrate macrofauna following sediment removal. Smothering impacts on remaining biota would thus be minimal. However, if tailings are deposited onto a portion of the as yet undisturbed beach below the plant site,the immediate impact would be the burial of the intertidal and subtidal macrofauna beneath a layer of sand and gravel. Depending on their size fraction, the sediments discharged in the intertidal zone would spread to a greater or lesser degree down the shore and into the surf zone where they would ultimately be redistributed by wave action and surf-zone currents. In the case of Walviskop, the virtually continuous discharge of tailings from the plant onto the beach may, however, exceed the ability of the southwards flowing counter current eddy to redistribute the tailings across the beach, potentially leading to accretion of the northern portion of the beach, with potential concomitant changes in the biophysical characteristics of the beach in the impact area (see section 4.3.2).

Factors known to determine the effect of burial on species are 1) the depth of burial; 2) the nature of depositing sediments; 3) burial time; 4) tolerance of species (life habitats, escape potential, tolerance to hypoxia etc.); 5) presence of contaminants in the depositing sediments, and 6) season (mortality rate by burial higher in summer than winter) (Kranz 1974; Maurer *et al*. 1981a, 1981b, 1982, 1986; Bijkerk 1988; Hall 1994; Baan *et al*. 1998; Harvey *et al*. 1998; Essink 1999; Schratzberger *et al*. 2000b; Baptist *et al*. 2009; Janssen *et al*. 2011). Many benthic invertebrates inhabiting unconsolidated sediments are able to burrow or move through the sediment matrix, and numerous studies have shown that some infaunal species are able to actively migrate vertically through overlying deposited sediment thereby significantly affecting the recolonisation and subsequent recovery of impacted areas (Maurer *et al*. 1979, 1981a, 1981b, 1982, 1986; Lynch 1994; Ellis 2000; Schratzberger *et al*. 2000a; but see Harvey *et al*. 1998; Blanchard & Feder 2003). Lynch (1994) conducted vertical migration experiments with beach macrofauna to determine their tolerance to sand overburdens, and found that several species were capable of burrowing through sediments between 60 and 90 cm, and Maurer *et al*. (1979) reported that some animals are capable of migrating upwards through 30 cm of deposited sediment. In contrast, consistent faunal declines were noted during deposition of mine tailings from a copper mine in British Columbia when the thickness of tailings exceeded 15-20 cm (Burd 2002), and Schaffner (1993) recorded a major reduction in benthic macrofaunal densities, biomass, and species richness in shallow areas in lower Chesapeake Bay subjected to heavy disposal (>15 cm) of dredged sediments. Similarly, Roberts *et al*. (1998) and Smith & Rule (2001) found difference in species composition detectable only if the layer of instantaneous applied overburden exceeded 15 cm. In general, mortality tends to increase with increasing depth of deposited sediments, and with speed and frequency of burial.

[2] In mining, gangue is the commercially worthless material that surrounds, or is closely mixed with, a wanted mineral in an ore deposit. In this case it would be the quarzitic sands.

The survival potential of benthic infauna, however, depends not only on their ability to migrate upwards through the deposited sediment, but also on the nature of the deposited sediments (Turk & Risk 1981; Chandrasekara & Frid 1998; Schratzberger *et al*. 2000a; Speybroeck *et al*. 2004). Although there is considerable variability in species response to specific sediment characteristics (Smit *et al*. 2006), higher mortalities were typically recorded when the deposited sediments have a different grain size composition from that of the receiving environment (Maurer *et al*. 1981a, 1981b, 1982, 1986; Smit *et al*. 2006; Smit *et al*. 2008), migration ability and survival rates generally being lower in silty sediments than in coarser sediments (Hylleberg *et al*. 1985; Ellis & Heim 1985; Maurer *et al*. 1986; Romey & Leiseboer 1989, cited in Schratzberger *et al*. 2000a; Schratzberger *et al*. 2000a). Some studies indicate that changes to the geomorphology and sediment characteristics may in fact have a greater influence on the recovery rate of invertebrates than direct burial or mortality (USDOI/FWS 2000). The availability of food in the depositional sediment is, however, also influential. In the case of the Whale Head Minerals operation, most of the fine sand fraction (75 – 180 µm) will have been removed in the WCP. The particle size distribution of the discharged tailings will therefore be skewed towards the medium, coarse and very coarse sand fractions and thus no longer resemble the native beach sediments.

The burial time, or duration of burial, will also determine the effect on benthos. Here a distinction must be made between incidental deposition, where species are buried by deposited material within a short period of time, and continuous deposition, where species are exposed to an elevated sedimentation rate over a long period of time (as would occur during tailings discharge at Walviskop). Whereas the volumes deposited per unit time will likely be lower under conditions of continuous deposition, such deposition can nonetheless have negative effects when the sedimentation rate is higher than the velocity at which the organisms can move or grow upwards. The sensitivity to long-term continuous deposition is species dependent and also dependent on the sediment type, with continuous deposition of silt being more lethal than a deposition of sand.

The nature of the receiving community is also of importance. In areas where sedimentation is naturally high (e.g. wave-disturbed shallow waters) the ability of taxa to migrate through layers of deposited sediment is likely to be well developed (Roberts *et al*. 1998). The life-strategies of organisms is a further aspect influencing the susceptibility of the fauna to mortality. Kranz (1972, cited in Hall 1994) studied the burrowing habits of 30 species of bivalves and showed that mucous-tube feeders and labial palp deposit-feeders were most susceptible to sediment deposition, followed by epifaunal suspension feeders, boring species and deep-burrowing siphonate suspension-feeders, none of which could cope with more than 1 cm of sediment overburden. Infaunal non-siphonate suspension feeders were able to escape 5 cm of burial by their native sediment, but normally no more than 10 cm. The most resistant species were deep-burrowing siphonate suspension-feeders, which could escape from up to 50 cm of overburden. Menn (2002) reported that meiofaunal species appeared less susceptible to burial than macrofauna, and Carey (2005) was unable to detect any effects of beach replenishment on benthic microalgae.

The exact depth of sand through which beach biota can successfully migrate ('fatal depth') thus depends on the species involved (reviewed by Essink 1993). Although numerous studies have investigated the burrowing efficiency of local species under different swash conditions or grain size composition (e.g. Brown & Trueman 1991, 1995; Nel *et al*. 2001), information on successful upward migration and survival following heavy deposition of sediments is largely lacking (but see Trueman & Ansell 1969). However, benthic organisms living in nearshore wave influenced areas in the Benguela region are likely to be adapted to relatively high sedimentation rates. Nonetheless, it is safe to assume that most beach infauna in the immediate vicinity of thetailings discharge footprint would be smothered.

Burial can also lead to a chain of other stressors on benthic species communities like oxygen depletion. These are discussed further in Section 4.3.2.

The localised impacts of smothering, burial and loss of intertidal and shallow subtidal benthic communities through tailings discharge and possible beach accretion is considered to be of medium intensityin the tailings discharge area. Impacts are likely to persist over the short-termonly as tailings would be redistributed by wave action. Even in the event of localised accretion opposite the discharge point, once discharges have ceased erosion of the accreted beach would occur over the short-term with redistribution of sediments across the length of the beach being facilitated by local rip currents and eddies. Smothering of beach macrofauna by discarded tailings is thus considered to be of **LOW** significance without mitigation and would be fully reversible. This would reduce to **INSIGNIFICANT** if tailings are returned to the mined out blocks.

<u>**Mitigation**</u>

The following mitigation measures are proposed:

- As far as practicable, return tailings to the mined out blocks to 1) reduce impacts on beach macrofauna in as yet undisturbed sections of the beach, 2) avoid potential accretion opposite the discharge point, and 3) fascilitate rehabilitation of mined out voids.

Smothering of benthic biota by discarded tailings		
	Without Mitigation	**Assuming Mitigation**
Intensity	Medium	Low
Duration	Short-term	Short-term
Extent	Local: limited to the discharge area	Local
Consequence	Very Low	Low
Probability	Probable	Possible
Significance	Low	Insignificant
Status	Negative	Negative
Confidence	High	High

Nature of Cumulative impact	Due to decades of coastal mining in the area cumulative impacts from heavy minerals mining can be expected
Reversibility	Fully reversible
Loss of resources	Low
Mitigation potential	High

4.2.2 Changes in Biophysical Characteristics

Previous studies on the impact of cofferdam and larger-scale seawall mining on macrofaunal beach communities identified that the physical state of beaches on the West Coast is entirely driven by natural conditions, and is not affected (except during actual mining) by beach mining operations in the medium- to long-term (Pulfrich *et al.* 2004; Pulfrich & Hutchings2019). Large-scale disturbances of beach habitat, associated with activities such as beach mining are evident on all the biotic parameters (abundance, biomass, species richness, and community structure), and at all taxonomic levels of the sandy beach infaunal communities (see also Defeo & Lecari 2003). However, if the surface sediment is similar to the native beach material when operations cease, and if the final long-term beach profile has similar contours to the original profile, the addition or removal of sediment does not have enduring adverse effects on the sandy beach benthos and recovery following the initial disturbance can occur within a few years (Hurme & Pullen 1988; Nel & Pulfrich 2002; Nel *et al.* 2003; Pulfrich *et al.* 2004; Pulfrich & Branch 2014).

In contrast, unsystematic garnet sand mining on dissipative beaches in India was found to significantly affect the morphology of impacted beaches, particularly the littoral zone. The exploitation of heavy mineral sands disrupted the beach stability, exaggerated erosion cycles in response to changing sea conditions thereby resulting in both spatial and temporal alterations of beach profiles and the development of ridge and runnel conditions (Chandrasekar *et al.* 2001; 2014). Long-term changes in beach morphology were also attributed to alteration of the longshore sediment transport due to mining of nearshore sediments from sand bars. Erosional conditions developed and persisted on exploited beaches as the quantity of sand mined exceeded the rate of onshore sediment transport (Saravanan & Chandrasekar 2010). Furthermore, removal of the heavy minerals fraction resulted in changes in the mean sand particle size of mined beaches, which in turn negatively affected the nesting success of horseshoe crabs and Olive Ridley turtles (Sengupta & Ghosal 2017).

Most of the material excavated from the heavy-mineral sands deposit on the Walviskop beach is sand, and fine silt. In other parts of the world, heavy minerals typically constitute 4-5% of the mineral sands(Motsi 2010; Pupienis *et al.* 2011; van Gosen *et al.* 2014). In the Walvis kop area, however, the heavy minerals fraction contributes between 40-50% to the sediments, mainly in the 75-180 µm range. Although some 50-60% of the mined sands will be returned to the beach, the particle size distribution of the discharged tailings will be skewed towards the medium, coarse and very coarse sand fractions and will thus no longer resemble the native beach sediments.

If the tailings from the plant are piped back to the mining area and used to refill the mined out blocks, the coarser tailings and oversize would settle rapidly into the excavated depressions upon discharge while the slimes would remain in suspension for longer, possibly resulting in suspended sediment plumes in the surf zone (see section . Where tailings are discharged into mined-out ponds differential settling rates will result in a layering effect in the discharged sediments, thereby affecting the natural stratification of the sediments. This will be temporary only as natural wave processes in the intertidal zone will ensure rapid re-sorting of the sediments. The nearshore sediment transport mechanisms that govern the natural sedimentary cyclewill with time replace the reducedfine sand fractions as part of the heavy minerals enrichment process on the beach.

Alternatively, if tailings are discharged onto the beach, the fines would be lost in the runoff, leaving the coarser fractions remaining on the beach surface.If discharge rates exceed the ability of the southwards flowing counter current eddy to redistribute the tailings across the beach, accretion of the shoreline opposite the discharge point on the northern portion of the beach will likely occur. Accretion of coarser sediments would in turn result in the steepening of the beach slope and concommitant changes in the wave climate (Pulfrich & Branch 2014).

On sandy beaches, the physical characteristics of the beach, namely the sand particle size, wave energy and beach slope, play an important role in determining the composition of the biological communities inhabiting the beach (McLachlan *et al.* 1993; McLachlan 1996). The nature of the discarded tailings will thus not only affect the immediate survival potential of impacted communities, but will determine the physical characteristics of the beach over the medium- to long-term. This in turn will influence the recovery rate of the impacted communities as well as the ultimate community structure (Pulfrich & Branch 2014a; Pulfrich & Hutchings 2019).When sediments deposited on beaches have similar properties (grain size and organic matter) to the native sediments, the addition of such sediments has the least impact on benthic infauna and the shortest recovery time of affected communities (Hayden & Dolan 1974; Culter & Mahadevan 1982; Gorzelany & Nelson 1987; Hurme & Pullen 1988; Nelson 1993; Löffler & Coosen 1995; Birklund *et al.* 1996; Le Roy *et al.* 1996; Rakocinski *et al.* 1996; Peterson *et al.* 2000; Van Dalfsen & Essink 2001; Menn 2002; Menn *et al.* 2003; Pulfrich *et al.* 2004; amongst other). Effects, however, differ depending on what part of the shore receive the additional material. When the application of sediments of similar size occurs high on the beach, recovery of infaunal communities occurs relatively quickly (reviewed in USACE 1989; Greene 2002), due to the gradual redistribution of sands across the beach (Dankers *et al.* 1983; Baptist *et al.* 2009). In contrast, communities in the deeper subtidal show higher sensitivity to disturbance due to a higher abundance of long-lived species than in the highly dynamic intertidal and surf-zones (Parr *et al.* 1978; Reise 1985; Brown & Mclachlan 1994; Rakocinski *et al.* 1996; Menn 2002).

The effects of adding sediments that poorly match the native beach sediments result in more substantial changes in macrofaunal community structure (Naqvi & Pullen 1982; Nelson 1989; Hackney *et al.* 1996; Peterson *et al.* 2000; Lindquist & Manning 2001; Peterson & Manning 2001; Bishop *et al.* 2006; Fanini *et al.* 2009). The addition of coarser sediments onto a beach results in changes in the beach morphodynamics, which in turn influences both the species diversity and abundance of the associated invertebrate fauna, thereby causing changes in community structure, as has been clearly demonstrated in numerous biological monitoring studies of beach mining operations in southern Namibia (Pulfrich 2004b; Clark *et al.* 2004, 2005, 2006; Pulfrich & Atkinson 2007; Pulfrich *et al.* 2007, 2008; Clark *et al.* 2009; Pulfrich *et al.* 2010, 2011; Pulfrich & Branch 2014; Pulfrich *et al.* 2015, 2016, 2017, 2018, 2019).

On sandy shores, all the sand sources and sinks are linked to one another, thereby forming a coastal sand system that is in a natural state of equilibrium. The removal or addition of sand to such a system can therefore be expected to affects all of the other parts of the system before a new equilibrium is formed. The removal of the heavy mineral component of the sediments at Walviskop is thus highly likely to result in localised changes in the physical characteristics of the impacted beaches, and changes in community structure of invertebrate macrofauna in response to these physical changes can be expected. Such changes are considered to be of medium intensity but limited to the Walviskop beach. Impacts are likely to persist over the short- to medium-term and are thus considered to be of **LOW** significance without mitigation, reducing to **VERY LOW** with mitigation.

Mitigation

Removal and processing of heavy mineral beach sands and discharge of tailings are all an integral part of the mining approach and other than the 'no-go' option, there is no feasible mitigation for these proposed operations.

Changes in community structure in response to alterations in the biophysical characteristics of the beach		
	Without Mitigation	**Assuming Mitigation**
Intensity	Medium	No mitigation is feasible
Duration	Medium-term	
Extent	Local: limited to the project area	
Consequence	Very Low	
Probability	Probable	
Significance	Low	
Status	Negative	
Confidence	High	

Nature of Cumulative impact	Due to decades of coastal mining in the area cumulative impacts from heavy minerals mining can be expected
Reversibility	Fully reversible
Loss of resources	Low
Mitigation potential	None

4.2.3 Disturbance of coastal biota by noise

During installation of infrastructure, and mining and processing of the mineral sands, noise and vibrations from excavation machinery and plants may have an impact on surf zone biota, marine mammals and shore birds in the area. Noise levels during construction are generally at a frequency much lower than that used by marine mammals for communication (Findlay 1996), and these are therefore unlikely to be significantly affected. Additionally, the maximum radius over which the noise may influence is very small compared to the population distribution ranges of surf zone fish species, resident cetacean species and the Cape fur seal. Both fish and marine mammals are highly mobile and should move out of the noise-affected area (Findlay 1996). Similarly, shorebirds and terrestrial biota are typically highly mobile and would be able to move out of the noise-affected area.

Disturbance and injury to marine biota due to construction noise is thus deemed of medium intensity within the immediate vicinity of the construction sites, with impacts persisting over the very short-term only.Whereas noise impacts on shorebirds is possible, fish and marine mammals in the area are unlikely to be affected. The impact of noise is therefore considered **INSIGNIFICANT**.

Mitigation

As the noise associated with construction is unavoidable, no direct mitigation measures, other than the no-project alternative, are possible. Impacts can however be kept to a minimum through responsible construction practices.

Disturbance of coastal biota by noise		
	Without Mitigation	**Assuming Mitigation**
Intensity	Medium	No mitigation is feasible
Duration	Short-term	
Extent	Local: limited to the project area	
Consequence	Very Low	
Probability	Improbable - Possible	
Significance	Insignificant	
Status	Negative	
Confidence	High	

Nature of Cumulative impact	Due to the remoteness of the area cumulitive noise impacts are unlikely
Reversibility	Fully reversible
Loss of resources	Low
Mitigation potential	Low

4.2.4 Accidents and Emergencies

The project activities that may result in operational spillsare described further below:

- Instantaneous spills of diesel and/or hydraulic fluid in the intertidal zone or at the surface of the sea can potentially occur during all project activity phases. Such spills are usually of a low volume and occur accidentally during fuel bunkering or as a result of hydraulic pipe leaks or ruptures.
- Mining infrastructure and equipment are stored and parked above the high water mark where accidental spills may occur during refuelling, or leaks may develop as a consequence of poor maintenance and neglect.

Onshore spills are likely to be of a low volume and occurring accidentally during refuelling of machinery or as a result of hydraulic pipe leaks or rupturesas a consequence of poor maintenance and neglect. As diesel tends to penetrate porous sediments quickly, spills in the supratidal and intertidal area would result in soil contamination. However, if spilled in the rocky intertidal, it would be washed off quickly by waves and tidal flushing as it is not very sticky or viscous.Althoughdegraded by naturally occurring microbes within one to two months diesel oil is considered to be acutely toxic to marine organisms. Consequently, intertidal invertebrates and seaweed that come in direct contact with a diesel spill may be killed.

A highly localised operational spill in the supratidal and intertidal would thus be of medium to high intensity in the short term.Small operational spills onshore are considered highly probably, but in most cases the impacts on biota can be considered of **LOW** significance before mitigation, reducing to **INSIGNIFICANT** with mitigation.Should they occur, impacts would be fully reversible.

Mitigation

The following mitigation measures are recommended:

- Seek to reduce the probabilities of accidental and/or operational spills through enforcement of stringent oil spill management systems. These should incorporate plans for emergencies and Environmental Awareness and Spill Training to ensure teh contractor and their staff are appropriately informed of how to deal with spills.
- Ensure good housekeeping practices are in place. This should include :
  - Place drip trays under all stationary machinery,
  - Bunding of all fuel storage areas,
  - Restrict vehicle maintenance to the maintenance yard area, except in emergencies when the beach area may be used if absolutely necessary
  - Maintain mining equipment to ensure that no oils, diesel, fuel or hydraulic fluids are spilled
- Refuelling must occur under controlled conditions only.

Impacts of an operational spill on intertidal and subtidal benthic macrofauna		
	Without Mitigation	**Assuming Mitigation**
Intensity	Medium to High	Very Low
Duration	Short-term	Short-term
Extent	Local	Local
Consequence	Low	Very Low
Probability	Probable	Possible
Significance	Low	Insignificant
Status	Negative	Negative
Confidence	High	High

Nature of Cumulative impact	Due to decades of coastal mining in the area cumulative impacts from heavy minerals mining can be expected
Reversibility	Fully reversible
Loss of resources	Low
Mitigation potential	Medium

4.3. Assessment of Indirect Impacts

4.3.1 Increased water turbidity and reduced light penetration

Suspended sediment plumes are generated by all mining operations, regardless of the mining approach. These occur near the seabed through re-suspension of fine sediments by the mining tool, by the discharge of tailings from processing plants into the sea, and by the constant erosion of finer materials from mining trenches by wave action.

The finer components generate a plume in the upper water column, which is dispersed away from the point of discharge by prevailing currents, diluting rapidly to background levels at increasing distances from the mining area. Distribution and re-deposition of suspended sediments are the result of a complex interaction between oceanographic processes, sediment characteristics and engineering variables that ultimately dictate the distribution and dissipation of the plumes in the water column. Ocean currents, both as part of the meso-scale circulation and due to local wind forcing, are important in distribution of suspended sediments. Turbulence generated by surface waves can also increase plume dispersion by maintaining the suspended sediments in the upper water column.

One of the more apparent effects of increased concentrations of suspended sediments and consequent increase in turbidity, is a reduction in light penetration through the water column with potential adverse effects on the photosynthetic capability of phytoplankton (and other aquatic plants) (Poopetch 1982; Kirk 1985; Parsons *et al.* 1986a, 1986b; Monteiro 1998; O'Toole 1997) and the foraging efficiency of visual predators (Clark *et al.* 1998; Simmons 2005; Braby 2009; Peterson *et al.* 2001).

Suspended sediments also load the water with inorganic particles, which may have biological effects such as a reduction of invertebrate egg and larval survival (thereby potentially affecting the recovery rate of the impacted shoreline), and diminish the filter-feeding efficiency of suspension feeders (reviewed by Clarke & Wilber 2000). Increased turbidity following addition of finer sediments during beach replenishment has been reported to result in increased mortality of adult surf clams, and reduced survival of juvenile surf clams and polychaetes, resulting in delayed recovery of impacted populations (Reilly & Bellis 1983; Rakocinski *et al.* 1996; Speybroek *et al.* 2005; but see also Spring 1981; Gorzelany & Nelson 1987). However, in most cases sub-lethal or lethal responses occur only at concentrations well in excess to those of sediment plumes from mining operations. Furthermore, as marine communities in the Benguela are frequently exposed to naturally elevated suspended-sediment levels, they can be expected to have behavioural and physiological mechanisms for coping with this feature of their habitat.

Poor visibility may also inhibit pelagic visual predators. A wide range of birds forage in or just behind the surf zone. Seabirds are visual predators that forage by sight and therefore need clear water to locate their prey. Most pelagic fish species, which form the major component of seabird diets, however, tend to avoid turbid waters. This is likely to affect local feeding efficiency of seabirds either by obscuring their vision or by potentially reducing prey availability through avoidance responses of prey species to turbid water areas. It is difficult to assess the significance of the potential impacts of mining-induced turbidity on seabird populations, as it largely depend on the extent and duration of the sediment plumes. If the plumes are highly localised and disperse quickly, then the consequences are likely to be negligible. Turbid water is a natural occurrence along the southern African west coast, resulting from aeolian and riverine inputs, resuspension of seabed sediments in the wave-influenced nearshore areas and seasonal phytoplankton production in the upwelling zones.

It is anticipated that the beach sediments in the mining target area have a negligible clay and silt fraction, so the generation of suspended sediment plumes above natural background levels are expected to be insignificant. Turbidity offshore of the mine site is thus unlikely to exceed levels attained naturally during turn-over of nearshore sediments by wave action or seasonal inputs from river discharges. As turbid water is a natural occurrence along the southern

African west coast, any turbidity-related effects in the near-shore environment as a direct result of mining operations are likely to be insignificant.

Due to the transient nature of suspended sediment plumes, the potential impacts are considered to be of low intensity, persisting only over the very short term (hours to days), and would be localised (<2 km radius of the mine site). Any possible adverse effects on sessile benthos, or on the feeding, spawning and recruitment of mobile predators, will be fully reversible.The biochemical impact of reduced water quality through increased turbidity can thus confidently be rated as being **INSIGNIFICANT** without mitigation. Suspended sediment concentrations within plumes are unlikely to exceed maximum levelsperiodically occurringnaturally along the wave-dominated coastline.

Mitigation

No mitigation measures other than the 'no-go' alternative are possible or deemed necessary for the resuspension of seabed sediments and the generation of turbid water plumes.

Impacts of suspended sediments on water column and bottom-water biochemistry (turbidity and light)		
	Without Mitigation	**Assuming Mitigation**
Intensity	Low	No mitigation is proposed
Duration	Short-term	
Extent	Local: limited to immediate vicinity of the mining area	
Consequence	Very Low	
Probability	Improbable	
Significance	Insignificant	
Status	Negative	
Confidence	High	

Nature of Cumulative impact	Due to decades of coastal mining in the area cumulative impacts from heavy minerals mining can be expected
Reversibility	Fully reversible
Loss of resources	Low
Mitigation potential	None

4.3.2 Hypoxia

Besides the physical effect of burial, a further indirect impact potentially associated with discharge of tailings onto the beach is the chemical effects of the waste material on the receiving communities. Studies from elsewhere have identified that the addition of either anaerobic sediments, or sediments with a high organic content, can result in the development of hypoxic/anoxic conditions in the sediments. Fine sediments are more likely to have a higher organic content and thus more likely to trigger a reduction in oxygen. Under conditions of limited oxygen, rates of nitrate and phosphate remineralisation, and sulfate reduction in the sediments increase. The resulting production of nitrite, ammonia, and sulfide in combination with low oxygen can have sub-lethal and lethal effects on benthic organisms (Baptist *et* *al.*2009). Decreased dissolved oxygen levels can thus amplify the effects of increased sedimentation.

The high wave exposure in combination with the comparatively coarse nature of the beach sedimentsin the project area make it highly unlikely that hypoxic conditions will develop as a consequence of the tailings discharge. The comparatively coarse sediment will ensure penetrability and flushing rates will remain high. Furthermore, the tailings will likely have a low organic content. The likelihood of hypoxic conditions developing in the discharge area is therefore very low. The potential impactsof hypoxia are considered to be of low intensity and as any effects would persist over the short-term only, they are considered to be of **INSIGNIFICANT** both without and with mitigation.

Mitigation
No mitigation measures are possible or deemed necessary.

Development of hypoxic sediments		
	Without Mitigation	**Assuming Mitigation**
Intensity	Low	No mitigation is proposed
Duration	Short-term: although hypoxic conditions would be transient, their effects on infaunal communities would extend over the short-term	
Extent	Local: limited to area of accretion	
Consequence	Very Low	
Probability	Possible	
Significance	Insignificant	
Status	Neutral: unlikely to vary beyond natural oxygen concentrations	
Confidence	High	

Nature of Cumulative impact	Biota in the Benguela ecosystem have behavioural and physiological mechanisms for coping with this feature of their habitat so cumulative impacts are unlikely
Reversibility	Fully reversible
Loss of resources	Low
Mitigation potential	None

4.3.3 Sediment mobilisation and redistribution

The fluidisation and (temporary) removal of beach sands and the discharge of tailings onto the beach will result in the mobilisation of sediments in the nearshore zone and their redistribution by wave action, rip currents and eddies until the long-term equilibrium profile of the beach is re-established. The addition of tailings on the northern portion of the beachmay result in beach accretion and the steepening of the beach profile, which in turn will lead to increased erosion of sediments by wave action. Some sediments will be carried offshore by undertow and rip currents and deposited beyond the surf zone, to be returned shoreward again in calm conditions. Modelling studies undertaken at Rooiwal Bay south of Hondeklipbaai suggested that sediments eroded off beaches in small baysis rapidly redistributed alongshore by wave-driven currents, initially leaking southwards out of the bays and ultimately extending seawards on the seabed to join the northward littoral drift (WSP 2015).

These indirect effects manifest themselves as the inundation of intertidal and shallow subtidal reefs by sand, and corresponding responses by the benthic faunal and floral communities. In South Carolina, the effects of increased siltation and smothering from sand movement following beach replenishment were considered to have a greater impact on hard substratum habitats than on the replenished sandy shoreline. Smothering of nearshore reef habitats resulted in the loss of productive fishing grounds and declines in the nearshore fish communities (Van Dolah *et al*. 1994). Monitoring in southern Namibia has shown that mobilisation and re-deposition of sediments from mining sites can have severe impacts on intertidal and shallow subtidal rocky shore habitats bordering the mined beaches and at some distance away, with both temporary and permanent loss of rocky intertidal habitats being reported as a result of shoreline accretion (Clark *et al*. 2004, 2005, 2006; Pulfrich & Atkinson 2007; Pulfrich *et al*. 2007, 2008; Pulfrich *et al*. 2010, 2011; Pulfrich & Branch 2014a, 2014b; Pulfrich et al 2015, 2016, 2017, 2018, 2019).

There are three possible avenues for depositing sediments to influence rocky-shore communities: (1) smothering that depletes all or some groups thereby affecting community diversity (Littler *et al*. 1983; McQuaid & Dower 1990); (2) alteration of supply of particulate materials with potential enhancement of suspension-feeders (Menge 1992); (3) ripple effects by which depletion of taxa in higher trophic levels influences the abundance of those in lower trophic levels (Littler & Murray 1975; Hawkins & Hartnoll 1983, Littler *et al*. 1983; Hockey & Bosman 1986; Branch *et al*. 1990; Eekhout *et al*. 1992). These predicted effects have all, to a greater of lesser extent, been observed in rocky shore communities in the vicinity of coastal mining operations in southern Namibia, and would, to some extent, be expected in the Walviskop area, especially on the rocky outcrop in the centre of the bay as well as to the north and south of the beach. Considering the scale of the proposed operation, the erosion and mobilisation of sediments during mining or from accreted portions of the shoreline is not expected to significantly exceed natural long-shore littoral drift, and natural cyclical sedimentation processes on adjacent rocky shores or nearshore reefs will in all likelihood mask any mining-related effects. Although likely only having very localised effects, it must be kept in mind that the Namaqua Mixed Shores habitatcharacterising the project area has been rated as 'vulnerable' and any deterioration or loss of such habitats should thus be actively avoided.

The impacts associated with the mobilisation and redistribution of sediments during mining and as a consequence of tailings discharges are considered to be of medium intensity and as theywould not persist beyond the short term, they are considered to be of MEDIUM significance both without and with mitigation.

Mitigation

No mitigation is feasible other than the 'no-go' option.

Sedimentation of intertidal and shallow subtidal reefs		
	Without Mitigation	**Assuming Mitigation**
Intensity	Medium	No mitigation is proposed
Duration	Short term: sediments in the nearshore will be continuously resuspended by wave action, Erosion of accreted sediments on rocky shores on the open coast will occur over the short term	
Extent	Local: extending beyond the boundary of the immediate mining target	
Consequence	Very Low	
Probability	Probable	
Significance	Very Low	
Status	Negative	
Confidence	High	

Nature of Cumulative impact	Cumulative impacts are possible during the life-of-mine
Reversibility	Fully reversible
Loss of resources	Low
Mitigation potential	None

4.3.4 Impacts on higher-order consumers

Although recovery of invertebrate macrofaunal communities following disturbance of beach habitats generally occurs within 3 – 5 years after cessation of the disturbance, the species inhabiting beaches are all important components of the sandy-beach food chain. Most are scavengers, particulate- and filter-feeders that depend on inputs of detritus or beach-cast seaweeds (Brown & Odendaal 1994). As such, they assimilate food sources available from the detrital accumulations typical of this coast and, in turn, become prey for surf-zone fishes and shorebirds that feed on the beach slope and in the swash and surf zones. By providing energy input to higher trophic levels, they are important in nearshore nutrient cycling. The reduction or loss of these assemblages in the long-term may thus have cascade effects through the coastal ecosystem (Dugan *et al*. 2003). Similarly, recovery of rocky intertidal habitats occurs over the short-term, but these also serve as important feeding habitats for shore birds. The negative effects on higher order consumers (surf-zone fish and shorebirds) of changes in abundance of macrofaunal prey items as a consequence of beach nourishment operations in North Carolina have been demonstrated (Peterson *et al*. 2000; Lindquist & Manning 2001). However, considering the extremely localised nature of the proposed mining operations in comparison to the available coastal feeding-ground habitat for the fish and shorebirds, and the relatively quick recovery of benthic communities following disturbance, the effects of these higher order consumers can be considered negligible (see also Essink 1997; Baptist *et al*. 2009).

Due to recovery over the short-term of the invertebrate communities that serve as a food source for higher-order consumers, the potential impacts are considered to be of low intensity and are thus considered to be **INSIGNIFICANT**.

Mitigation

No mitigation is feasible other than the ‘no-go’ option.

Indirect effects on higher-order consumers		
	Without Mitigation	**Assuming Mitigation**
Intensity	Low	No mitigation is proposed
Duration	Short-term: as recovery of invertebrate communities that serve as food sources occurs within 2-5 years	
Extent	Local: limited to mining area	
Consequence	Very Low	
Probability	Improbable	
Significance	Insignificant	
Status	Negative	
Confidence	High	

Nature of Cumulative impact	Cumulative impacts are unlikely as being highly mobile, affected species can move to adjacent available feeding grounds
Reversibility	The impact is fully reversible
Loss of resources	Low
Mitigation potential	None

4.4. No-development Alternative

The “no-development” alternative implies that the heavy mineral sands beach mining operationdoes not go ahead. From a marine perspective this is undeniably the preferred alternative, as all impacts associated with beach disturbance, shoreline changes, loss of biota, unplanned pollution events and indirect sedimentation will not be realised. This must, however, be seen in context with existing mining and exploration rights and sustainability of the associated mines, and thus needs to be weighed up against the potential positive socio-economic impacts undoubtedly associated with accessing the potentially rich placer deposits present in the surf zone.

4.5. Cumulative Impacts

In the context of beach mining operations, a cumulative impact on the beach habitat and its associated macrofaunal communities would be an impact:

- which occurs on a beach which is experiencing, has experienced, or may foreseeably experience similar impacts in the future (e.g. either further diamond mining or heavy mineral sands mining in the same area),

- where there is the potential for synergistic interaction between impacts (*i.e.*diamond mining and heavy mineral sands mining impacts interact with each other to produce a total effect greater than the sum of the component impacts), and/or
- where ecological thresholds may be breached by a number of consecutive or simultaneous impacts, which individually may not have resulted in impacts.

The Whale Head Minerals project area is located within Alexkor's diamond Mining Licence Area (Mining Right 554MRC). The beaches and shallow subtidal areas have been prospected and mined for diamonds by Alexkor's contractors for decades. The beach mining involves using heavy earth-moving machinery to strip the sandy overburden for construction of seawalls near the low tide level, to exclude the encroaching sea and thereby extending the time available for mining the underlying gravels. The mining approach is therefore similar to that proposed for mining the heavy mineral sands in that portions of the beach are severely disturbed by excavations, ore transfer and processing operations and heavy vehicle traffic. As the Alexkor contractors are currently active along much of the coastline, any further mining ventures in the area during the next 5 years will at the very least result in additive cumulative impacts to the invertebrate macrofaunal communities inhabiting the beach sediments, potentially with synergistic and both space- and time-crowding effects as well.

However, the significance of this needs to be seen in the context of the short-and long-term natural disturbances characterising the nearshore marine environment in the Benguela region and the robustness of the marine biota in coping with, and recovering from, these. From the monitoring studies of the large-scale and long-term beach mining operations in southern Namibia, it is apparent that despite the substantial cumulative impacts of decades of seawall mining operations and large-volume sediment discharges, the macrofaunal communities respond rapidly to the cessation of the mining disturbance. Evidence therefore suggests that provided there are no significant changes to the physical characteristics of the beach in the short-term, the likely cumulative impacts of beach mining for both diamonds and heavy mineral sands in the Walviskop area is not expected to have enduring adverse effects on the sandy beach benthos.

Although the area of Namaqua Mixed Shore targeted for heavy mineral mining amounts to only a fraction of the total habitat type in the region,the cumulative impact of years of mining by an increasing number or contractors applying progressively modern techniques to locate and access deposits must be kept in mind. Considering the vulnerability of the habitat types in the mining licence area and the decades of uncontrolled and environmentally irresponsible operations these cumulative impacts are considered to be of **MEDIUM** significance. Detailed records of annual and cumulative areas mined should be maintained by Whale Head Minerals, and submitted to the authorities should future informed decisions need to be made regarding disturbance limits to benthic habitat types in the Namaqua Bioregion.

4.6. Project Controls

A generic Environmental Code of Practice (ECOP) was developed for Walpomp operations in the surf zone and shallow portions of Sea Concessions 1a, 2a and 3a (see Appendix 1 of main EIA report) as part of the 2017 Alexkor EMPr Amendment (SLR 2018). Contractors undertaking heavy mineral mining would be required to comply with the environmental specifications in that ECOP pertaining to:

- housekeeping;
- fuel and lubricant storage and management;
- refuelling;
- hydrocarbon contamination;
- solid waste management;
- oil spill procedure and reporting; and
- weekly monitoring.

5. CONCLUSIONS

The impacts on marine habitats and communities associated with the proposed mining for heavy minerals at Walviskop are summarised in the Table below (Note: * indicates that no mitigation is possible, thus significance rating remains).

Impact	Significance (before mitigation)	Significance (after mitigation)
Destruction and loss of supratidal habitats and associated biota	High	Low
Disturbance and loss ofintertidal and shallow subtidal sandy beach macrofauna	Medium	Very Low
Smothering of benthic biota by discarded tailings	Low	Insignificant
Changes in community structure in response to alterations in the biophysical characteristics of the beach	Low	Low*
Impacts of noise from mining operations on coastal biota	Insignificant	Insignificant*
Impacts of an operational spill on intertidal and subtidal benthic macrofauna	Low	Insignificant
Impacts of tailings discharge on water column and bottom-water biochemistry (turbidity and light)	Insignificant	Insignificant*
Indirect Impacts of tailings discharges: development of anoxic sediments	Insignificant	Insignificant*
Sedimentation of intertidal and shallow subtidal reefs	Very Low	Very Low*
Impacts of mining operations on higher-order consumers	Insignificant	Insignificant*

5.1. Environmental Acceptability and Impact Statement

The main marine impacts associated with the proposed mining activities are related to disturbance and loss of sandy and rocky habitats and their associated benthic flora and fauna in the mining footprint. From the results of past studies, it is now well established that mining in the intertidal zone of sandy beaches severely influences the diversity and community structure of the invertebrate macrofauna of the beach itself, and potentially the benthic biota of adjacent rocky intertidal and shallow subtidal habitats as well. However, as removal and treatment of beach sediments are an unavoidable consequence of the proposed mining, there can be no direct mitigation for their impacts on marine biological communities. Other than the 'no go' option, the impacts to the intertidal and shallow subtidal marine biota are thus unavoidable should mining go ahead. As mining operations have been ongoing along this section of the coast for decades, however, the proposed mining target cannot be considered particularly 'pristine'. Nonetheless, from a marine perspective the 'no go' option is undeniably the preferred alternative, as all impacts associated with the disturbance of beach and rocky habitats would no longer be an issue.

The highly localised, yet significant impacts of heavy minerals mining in the Walviskop pocket beach will endure over the short- to medium term, and these impacts thus need to be weighed up against the benefits of the mining project. Provided the impacts are meticulously managed and pro-active rehabilitation is undertaken as far as is feasible in the coastal environment, there is no reason why the proposed mining of the heavy mineral sands at Walviskop should not go ahead.

5.2. Mitigation Measures and Management Actions

Environmental management actions for implementation in Whale Head Minerals's Environmental Management Plan should focus on the following aspects to be considered prior to, during and on cessation of mining activities in an area:

- Develop the mine plan to ensure that mining proceeds systematically and efficiently from one end of the target area to the next, and that the target area is mined to completion in as short a time as possible.
- To allow impacted communities to recover to a condition where they are functionally equivalent to the original condition, the beaches should not be re-mined for at least five years, if at all. Efficient, high intensity mining methods are thus preferable to repeated operations.
- To prevent degradation of the sensitive high-shore beach areas, all activities must be managed according to a strictly enforced Environmental Management Plan. High safety standards and good house-keeping must form an integral part of any operations on the shore from start-up, including, but not limited to:
  - drip trays and bunding under all vehicles and equipment on the shore where losses are likely to occur;
  - no vehicle maintenance or refuelling on shore;
  - accidental diesel and hydrocarbon spills to be cleaned up accordingly; and
  - collect and dispose polluted soil at appropriate bio-remediation sites.
- To avoid unnecessary disturbance of communities and destruction of habitats, heavy vehicle traffic in the high- and mid-shore must be limited to the minimum required, and must be restricted to clearly demarcated access routes and operational areas only. The operational footprint of the mining site should be minimised as far as practicable.
- Initiate restoration and rehabilitation as soon as mining is complete in an area. This should involve back-filling excavations using tailings and discards and restoring the beach profile to that resembling the pre-mining situation. No accumulations of tailings should be left above the high water mark.
- On cessation of operations, all mining equipment, artificial constructions or beach modifications created during mining must be removed from above and within the intertidal zone.
- Possible ways of minimising the risk of cumulative impacts are provided below, but the feasibility of these is uncertain and should be weighed up against the apparent robustness of the beach macrofaunal communities to large-scale and long-term disturbance:
  - Compile the mine plan in close collaboration with Alexkor so that areas are mined concurrently rather than in succession;
  - Areas previously mined by Alexkor should notbe re-mining for heavy mineral sands within 5 years of Alexkor's operations ceasing in that section of the beach; or
  - The 'no-development' option.

6. LITERATURE CITED

AIROLDI, L., 2003. The effects of sedimentation on rocky coast assemblages. *Oceanogr. Mar. Biol. Ann. Rev.*, 41: 161–236.

AIROLDI, L., RINDI, F. and F. CINELLI, 1995. Structure, seasonal dynamics and reproductive phenology of a filamentous turf assemblage on a sediment influenced, rocky subtidal shore. *Bot. Mar.*, 38(3): 227-237.

ALONSO, J., ALCANTARA-CARRIO & J. CABRERA, 2002. Tourist resorts and their impact on beach erosion at Sotavento Beaches, Fuerteventura, Spain. *Journal of Coastal Research*, **36**:1-7.

ANCHOR ENVIRONMENTAL CONSULTANTS, 2010. Marine Specialist Impact Assessment for a Proposed Reverse Osmosis Desalination Plant at Port Nolloth. Prepared for BV1 Consulting Engineers (Springbok). October 2010. 50pp.

ANDERSON, R.J., ANDERSON, D.R. and J.S.ANDERSON, 2008. Survival of sand-burial by seaweeds with crustose bases or life-history stages structures the biotic community on an intertidal rocky shore. *Botanica Marina* 51, 10-20.

ANDERSON, R.J., SIMONS, R.H. and N.G. JARMAN, 1989. Commercial seaweeds in southern Africa: a review of utilization and research. *South African Journal of Marine Science***8**: 277-299.

AWAD, A.A., GRIFFITHS, C.L. & J.K. TURPIE, 2002. Distribution of South African benthic invertebrates applied to the selection of priority conservation areas. *Diversity and Distributions***8**: 129-145.

BAAN, P.J.A., MENKE, M.A., BOON, J.G., BOKHORST, M., SCHOBBEN, J.H.M. & C.P.L. HAENEN, 1998. R*isico Analyse Mariene Systemen (RAM). Verstoring door menselijk gebruik.* Waterloopkundig Laboratorium, Delft.

BAILEY, G.W., 1991. Organic carbon flux and development of oxygen deficiency on the modern Benguela continental shelf south of 22°S: spatial and temporal variability. In: TYSON, R.V., PEARSON, T.H. (Eds.), Modern and Ancient Continental Shelf Anoxia. *Geol. Soc. Spec. Publ.*, **58**: 171–183.

BAILEY, G.W., 1999. Severe hypoxia and its effect on marine resources in the southern Benguela upwelling system. Abstract, *International Workshop on Monitoring of Anaerobic processes in the Benguela Current Ecosystem off Namibia.*

BAILEY, G.W., BEYERS, C.J. DE B. and S.R. LIPSCHITZ, 1985. Seasonal variation of oxygen deficiency in waters off southern South West Africa in 1975 and 1976 and its relation to catchability and distribution of the Cape rock-lobster *Jasus lalandii*. *S. Afr. J. Mar. Sci.*, **3**: 197-214.

BAILEY G.W. and P. CHAPMAN, 1991. Chemical and physical oceanography. In: Short-term variability during an Anchor Station Study in the southern Benguela Upwelling system. *Prog. Oceanogr.*, **28**: 9-37.

BALLY, R., 1987. The ecology of sandy beaches of the Benguela ecosystem. *S. Afr. J. mar. Sci.*, 5: 759-770

BAPTIST, M.J., TAMIS, J.E., BORSJE, B.W. & J.J. VAN DER WERF, 2009. *Review of the geomorphological, benthic ecological and biogeomorphological effects of nourishments on the shoreface and surf zone of the Dutch coast*. Report IMARES C113/08, Deltares Z4582.50, pp69.

BARENDSE, J., BEST, P.B., THOMTON, M., POMILLA, C. CARVALHO, I. and H.C. ROSENBAUM, 2010. Migration redefined ? Seasonality, movements and group composition of humpback whales *Megaptera novaeangliae* off the west coast of South Africa. *Afr. J. mar. Sci.*, **32(1)**: 1-22.

BARENDSE, J., BEST, P.B., THORNTON, M., ELWEN, S.H., ROSENBAUM, H.C., CARVALHO, I., POMILLA, C., COLLINS, T.J.Q. and M.A. MEŸER, 2011. Transit station or destination? Attendance patterns, regional movement, and population estimate of humpback whales *Megaptera novaeangliae* off West South Africa based on photographic and genotypic matching. *African Journal of Marine Science*, **33(3)**: 353-373.

BARKAI, A. and G.M.BRANCH, 1988. Contrasts between the benthic communities of subtidal hard substrata at Marcus and Malgas Islands: a case of alternative states? *S Afr J mar Sci***7**: 117-137.

BERG, J.A. and R.I.E. NEWELL, 1986. Temporal and spatial variations in the composition of seston available to the suspension-feeder *Crassostrea virginic*a. *Estuar. Coast. Shelf. Sci.*, **23**: 375–386.

BEST, P.B., 2001. Distribution and population separation of Bryde's whale *Balaenoptera edeni* off southern Africa. *Mar. Ecol. Prog. Ser.*, 220: 277 – 289.

BEST, P.B., 2007. Whales and Dolphins of the Southern African Subregion. Cambridge University Press, Cape Town, South Africa.

BEST, P.B. and C.H. LOCKYER, 2002. Reproduction, growth and migrations of sei whales *Balaenoptera borealis* off the west coast of South Africa in the 1960s. *South African Journal of Marine Science*, **24**: 111-133.

BEST P.B., MEŸER, M.A. and C. LOCKYER, 2010. Killer whales in South African waters – a review of their biology. *African Journal of Marine Science*. **32**: 171–186.

BICCARD, A., GIHWALA, K., CLARK, B.M., MOSTERT, B., BROWN, E., HUTCHINGS, K., MASSIE, V. and M. MELIDONIS, 2018. Desktop study of the potential impacts of marine mining on marine ecosystems and marine biota in South Africa – Final report. Report prepared by Anchor Research & Monitoring (Pty) Ltd for Council for Geoscience. Report no. 1795/1.

BIJKERK, R., 1988. Ontsnappen of begraven blijven. De effecten op bodemdieren van een verhoogde sedimentatie als gevolg van baggerwerkzaamheden., RDD Aquatic Systems.

BISHOP, M.J., PETERSON, C.H., SUMMERSON, H.C., LENIHAN, H.S. & J.H. GRABOWSKI, 2006. Deposition and long-shore transport of dredge spoils to nourish beaches: Impacts on benthic infauna of an ebb-tidal delta. *Journal of Coastal Research*, **22**: 530-546.

BIRKLUND, J., TOXVIG, H. & C. LAUSTRUP, 1996. RIACON Evaluation of the nourishment and sand extraction of Torsminde Denmark. The Danish Coastal Authority in cooperation with the VKI, Draft Final Report: 65 pp

BLABER, S.J.M. and T.G. BLABER, 1980. Factors affecting the distribution of juvenile estuarine and inshore fish. *J. Fish Biol.*, 17: 143-162.

BLANCHARD, A.L. and H.M. FEDER, 2003. Adjustment of benthic fauna following sediment disposal at a site with multiple stressors in Port Valdez, Alaska. *Marine Pollution Bull*etin, **46**: 1590-1599.

BOLTON, J.J., 1986. Seaweed biogeography of the South African west coast - A temperature dependent perspective. *Bot. Mar.*, **29**: 251-256.

BORGES, P. ANDRADE, C. & M.C. FREITAS, 2002. Dune, bluff and beach erosion due to exhaustive sand mining – the case of Santa Barbara Beach, Sao Miguel (Azores, Portugal). *Journal of Coastal Research*, **36**: 89-95.

BOYD, A..J. and G.P.J. OBERHOLSTER, 1994. Currents off the west and south coasts of South Africa. *S. Afr. Shipping News and Fish. Ind. Rev.*, **49**: 26-28.

BOYD, S.E., LIMPENNY, D.S., REES, H.L. & K.M. COOPER, 2005. The effects of marine sand and gravel extraction on the macrobenthos at a commercial dredging site (results 6 years post-dredging). *ICES Journal of Marine Science*, **62**: 145-162.

BRABY, J., 2009. The Damara Tern in the Sperrgebiet: Breeding productivity and the impact of diamond mining. Unpublished report to Namdeb Diamond Corporation (Pty) Ltd.

BRANCH, G.M., 2008. Trophic Interactions in Subtidal Rocky Reefs on the West Coast of South Africa. In: MCCLANAHAN, T. and G.M. BRANCH (eds). Food Webs and the Dynamics of Marine Reefs. New York: Oxford University Press, 2008. Oxford Scholarship Online.Oxford University Press. pp 50-79

BRANCH, G. and M. BRANCH, 2018. Living Shores : Interacting with southern Africa's marine ecosystems. Struik Nature. Cape Town, South Africa.

BRANCH, G.M. and C.L. GRIFFITHS, 1988. The Benguela ecosystem part V: the coastal zone. *Oceanog. Marine Biology: An Annual Re*view, **26**: 395-486.

BRANCH, G.M., EEKHOUT, S. & A.L. BOSMAN, 1990. Short-term effects of the 1988 Orange River floods on the inter-tidal rocky-shore communities of the open coast. *Transactions of the Royal Society of South Africa*, **47**: 331-354.

BRANCH, G.M., GRIFFITHS. C.L., BRANCH, M.L. and L.E. BECKLEY, 2010. Two Oceans - A guide to the marine life of Southern Africa, David Philip, Cape Town and Johannesburg. Revised edition

BRANDÃO, A., VERMEULEN, E., ROSS-GILLESPIE, A., FINDLAY, K. & D.S. BUTTERWORTH, 2018. Updated application of a photo-identification based assessment model to southern right whales in South African waters, focussing on inferences to be drawn from a series of appreciably lower counts of calving females over 2015 to 2017. Paper Sc/67B/SH/22 submitted to the scientific Committee of the International Whaling Commission, Bled, Slovenia, May 2018

BREMNER, J.M., ROGERS, J. and J.P. WILLIS, 1990. Sedimentological aspects of the 1988 Orange River floods. *Trans. Roy. Soc. S. Afr.* **47** : 247-294.

BROUWER, S.L., MANN, B.Q., LAMBERTH, S.J., SAUER, W.H.H. and C. ERASMUS, 1997. A survey of the South African shore angling fishery. *South African Journal of Marine Science***18**: 165-178.

BROWN, A.C. and F.J. ODENDAAL, 1994. The biology of Oniscid Isopoda of the genus *Tylos*. *Adv. Mar. Biol.*, **30**: 89-153.

BROWN, A.C. AND A. McLACHLAN, 2002. Sandy shore ecosystems and the treats facing them: some predictions for the year 2025. *Environmental Conservation,***29 (1)**:1-16.

BROWN, A.C., STENTON-DOZEY, J.M.E. and E.R. TRUEMAN, 1989. Sandy beach bivalves and gastropods: a comparison between *Donax serra* and *Bullia digitalis*. *Adv. Mar. Biol.,***25**: 179-247.

BROWN, A.C. & E.R. TRUEMAN, 1991. Burrowing of sandy-beach molluscs in relation to penetrability of the substratum. *Journal of Molluscan Studies*, **57**: 134–136.

BROWN, A.C. & E.R. TRUEMAN, 1995. Burrowing behaviour and cost in the sandy-beach oniscid isopod *Tylos granulatus* Krauss 1843. *Crustaceana*, **69 Ž4:** 425–437.

BROWN, P.C., 1984. Primary production at two contrasting nearshore sites in the southern Benguela upwelling region, 1977-1979. *S. Afr. J. mar. Sci.*, **2** : 205-215.

BROWN, P.C. and J.L. HENRY, 1985. Phytoplankton production, chlorophyll a and light penetration in the southern Benguela region during the period between 1977 and 1980. In: SHANNON, L.V. (Ed.) South African Ocean Colour and Upwelling Experiment. Cape Town, SFRI : 211-218.

BRICELJ, V.M. and R.E. MALOUF, 1984. Influence of algal and suspended sediment concentrations on the feeding physiology of the hard clam *Mercenaria mercenari*a. *Mar. Biol.*, **84**: 155–165.

BURD, B.J., 2002. Evaluation of mine tailings effects on a benthic marine infaunal community over 29 years. *Marine Environmental Research*, **53**: 481-519.

BURKE, A. and J. RAIMONDO, 2002. Chameis Pocket Beach Areas Environmental Study: Environmental Impact Assessment and Environmental Management Plan. EIA and EMP prepared for Namdeb Diamond Corporation (Pty) Ltd. October 2002.

BUSTAMANTE, R.H. and G.M. BRANCH, 1996a. Large scale patterns and trophic structure of southern African rocky shores: the role of geographic variation and wave exposure. *J. Biog.,***23**: 339-351.

BUSTAMANTE, R.H. and G.M. BRANCH, 1996b. The dependence of intertidal consumers on kelp-derived organic matter on the west coast of South Africa. *J. Exp. Mar. Biol. Ecol.*, **196**: 1-28.

BUSTAMANTE, R.H., BRANCH, G.M. and S. EEKHOUT, 1995. Maintenance of exceptional intertidal grazer biomass in South Africa: Subsidy by subtidal kelps. *Ecology***76(7)**: 2314-2329.

BUSTAMANTE, R.H., BRANCH, G.M. and S. EEKHOUT, 1997. The influences of physical factors on the distribution and zonation patterns of South African rocky-shore communities. *S. Afr. J. mar. Sci.*, **18**: 119-136.

CALLIARI, L.J. KLEIN, A.H.F. & BARROS, F.C. R, 1996. Beach differentiation along the Rio Grande do Sul coastline (Southern Brazil). *Revista Chilena de Historia Natural*, **69**: 485-493.

CAREY, E.S., 2005. *The Effects of Beach Renourishment on Benthic Microalgae*. Unpublished MSc Thesis, University of North Carolina, Wilmington

CHANDRASEKARA, W.U. & C.L.J. FRID, 1998. A laboratory assessment of the survival and vertical movement of two epibenthic gastropod species, *Hydrobia ulvae* (Pennant) and *Littorina littorea* (Linnaeus), after burial in sediment. *Journal of Experimental Marine Biology and Ecol*ogy, **221**: 191-207.

CHANDRASEKAR, N., ANIL CHERIAN, RAJAMANICKAM, M. & G.V.RAJAMANICKAM, 2001. Influence of garnet sand mining on beach sediment dynamics between Periyathalai and Navaladi Coast, Tamilnadu. J. Ind. Assn. Sed., 21(1): 223-233.

CHANDRASEKAR, N., SARAVANAN, S., RAJAMANICKAM, M. & G.V. RAJAMANICKAM, 2014. The Spatial Variability of Ridge and Runnel Beach Morphology Due to Beach Placer Mining along the Vembar – Kallar Coast, India. Annales Universitatis Mariae Curie - Skłodowska Lublin – Polonia, 69(2): 53-68.

CHAPMAN, P. and L.V. SHANNON, 1985. The Benguela Ecosystem. Part II. Chemistry and related processes. *Oceanogr. Mar. Biol. Ann. Rev.*, **23**: 183-251.

CHENELOT, H., JEWETT, S. & M. HOBERG, 2008. Invertebrate Communities Associated with Various Substrates in the Nearshore Eastern Aleutian Islands, with Emphasis on Thick Crustose Coralline Algae. In: BRUEGGEMAN, P. & N.W. POLLOCK (eds.) Diving for Science. Proceedings of the American Academy of Underwater Sciences 27th Symposium.Dauphin Island, Alaska, AAUS, pp13-36.

CHESHIRE, A.C. & D.J. MILLER. 1999. The impact of sand dredging on benthic community structure at Pt Stanvac Dredge Site 4: Final report on the results of surveys 1992 to 1999. Department of Environmental Biology, University of Adelaide.

CLARK, B.M., 1997a. Variation in surf zone fish community structure across a wave exposure gradient. *Estuarine & Coastal Shelf Science***44**: 659-674.

CLARK, B.M., 1997b. Dynamics and Utilisation of Surf Zone Habitats by Fish in the South-Western Cape, South Africa. Unpublished PhD Thesis, University of Cape Town.

CLARK, B.M., BENNETT, B.A. and S.J. LAMBERTH, 1994. A comparison of the ichthyofauna of two estuaries and their adjacent surf-zones, with an assessment of the effects of beach-seining on the nursery function of estuaries for fish. *South African Journal of Marine Science* **14**: 121-131.

CLARK, B.M., MEYER, W.F., EWART-SMITH, C, PULFRICH, A. and J. HUGHES, 1999. Synthesis and assessment of information on the BCLME, Thematic Report 3: Integrated overview of diamond mining in the Benguela Current region. AEC Report # 1016/1 to the BCLME. 63pp.

CLARK, B.M., SMITH, C.E. & W.F. MEYER, 1998. *Ecological effects of fine tailings disposal and marine diamond pumping operations on surf zone fish assemblages near Lüderitz, Namibia.* Report to Namdeb Diamond Corporation (Pty) Ltd., Oranjemund, Namibia. 46pp.

CLARKE, D.G. and D.H. WILBER, 2000. Assessment of potential impacts of dredging operations due to sediment resuspension. *DOER Technical Notes Collection (ERDC TN-DOER-E9)*, U.S. Army Engineer Research and Development Center, Vicksburg, MS. www.wes.army/mil/el/dots/doer.

COCKCROFT, A. and A.J. MACKENZIE, 1997. The recreational fishery for West Coast rock lobster *Jasus lalandii* in South Africa. *South African Journal of Marine Science*, 18: 75-84

COCKCROFT, A.C, SCHOEMAN, D.S., PITCHER, G.C., BAILEY, G.W.AND D.L. VAN ZYL, 2000. A mass stranding, or 'walk out' of west coast rock lobster, *Jasus lalandii*, in Elands Bay, South Africa: Causes, results and implications. In: VON VAUPEL KLEIN, J.C.and F.R. SCHRAM (Eds), *The Biodiversity Crisis and Crustacea: Proceedings of the Fourth International Crustacean Congress*, Published by CRC press.

CRAWFORD, R.J.M., SHANNON, L.V. and D.E. POLLOCK, 1987. The Benguela ecosystem. 4. The major fish and invertebrate resources. *Oceanogr. Mar. Biol. Ann. Rev.*, **25**: 353 - 505.

CROWTHER CAMPBELL and ASSOCIATES CC and CENTRE FOR MARINE STUDIES (CCA and CMS). 2001. Generic Environmental Management Programme Reports for Oil and Gas Prospecting off the Coast of South Africa. Prepared for Petroleum Agency SA, October 2001.

CSIR, 1994. Alexkor Environmental Management Programme. 3 Volumes.

CSIR, 1996. Elizabeth Bay monitoring project: 1995 review. *CSIR Report ENV/S-96066.*

CULTER, J.K. & S. MAHADEVAN, 1982. Long-term Effects of Beach Nourishment on the Benthic Fauna of Panama City, Florida. *U.S. Army Corps of Engineers, Coastal Engineering Research Center, Misc. report*. No. 82-2.

DALY, M.A. and A.C. MATHIESON, 1977. The effects of sand movements on intertidal seaweeds and selected invertebrates at Bound Rock, New Hampshire. *Mar. Biol.*, **43**:45-55.

DANKERS, N., BINSBERGEN, M. & K. ZEGERS, 1983. De effecten van zandsuppletie op de fauna van het strand van Texel en Ameland., Rijksinstituut voor Natuurbeheer.

DAVID, J.H.M, 1989., Seals. In: Oceans of Life off Southern Africa, Eds. Payne, A.I.L. and Crawford, R.J.M. Vlaeberg Publishers. Halfway House, South Africa.

DE DECKER, A.H., 1970. Notes on an oxygen-depleted subsurface current off the west coast of South Africa. *Invest. Rep. Div. Sea Fish. South Africa*, **84**, 24 pp.

DE GREEF, K., GRIFFITHS, C.L. and Z. ZEEMAN, 2013. Deja vu? A second mytilid mussel, *Semimytilus algosus*, invades South Africa's west coast. *African Journal of Marine Science***35(3)**: 307-313.

DE WAAL, S.W.P., 2004. Stock assessment, Port Nolloth Sea Farms abalone (*Haliotis midae*) ranching project. Report to The Industrial Development Corporation of South Africa (Ltd), 58p.

DE WAAL, S.W.P. and P. COOK, 2001. Quantifying the physical and biological attributes of successful ocean seeding sites for farm reared juvenile abalone (*Haliotis midae*). *J Shellfish Res.*, **19**: 857-861.

DEFEO, O. & A. DE ALAVA, 1995. Effects of human activities on long-term trends in sandy beach populations: wedge clam Donax hanleyanus in Uruguay. *Marine Ecology Progress Series*, **123**: 73-82.

DEFEO, O & D. LECARI, 2003. Testing taxonomic resolution levels for ecological monitoring in sandy beach macrobenthic communities. Aquatic Conservation: Marine and Freshwater Systems, 14: 65-74.

DRAKE, D.E., CACCHIONE, D.A. and H.A. KARL, 1985. Bottom currents and sediment transport on San Pedro Shelf, California. *J. Sed. Petr.*, **55**: 15-28.

DUGAN J.E., HUBBARD, D.M., MCCRARY, M.D. & M.O. PIERSON, 2003. The response of macrofauna communities and shorebirds to macrophyte wrack subsidies on exposed sandy beaches of southern California. *Estuarine, Coastal and Shelf Science*, **58S**: 133-148.

DUNDEE, B.L., 2006. *The diet and foraging ecology of chick-rearing gannets on the Namibian islands in relation to environmental features: a study using telemetry*. MSc thesis, University of Cape Town, South Africa.

EEKHOUT, S., RAUBENHEIMER, C.M., BRANCH, G.M., BOSMAN, A.L. & M.O. BERGH, 1992. A holistic approach to the exploitation of intertidal stocks: limpets as a case study. *South African Journal of Marine Science*, **12**: 1017-1029.

ELLIS, D.V., 2000. Effect of Mine Tailings on The Biodiversity of The Seabed: Example of The Island Copper Mine, Canada. In: SHEPPARD, C.R.C. (Ed), Seas at The Millennium: An Environmental Evaluation. Pergamon, Elsevier Science, Amsterdam, pp. 235-246.

ELLIS, D.V. & C. HEIM, 1985. Submersible surveys of benthos near a turbidity cloud. *Marine Pollution Bulletin*, **16**: 197-202.

ELWEN, S.H. and R.H. LEENEY, 2011. Interactions between leatherback turtles and killer whales in Namibian waters, including predation. *South African Journal of Wildlife Research,***41(2)**: 205-209.

ELWEN, S.H. MEŸER, M.A.M, BEST, P.B., KOTZE, P.G.H, THORNTON, M. and S. SWANSON, 2006. Range and movements of a nearshore delphinid, Heaviside's dolphin *Cephalorhynchus heavisidii* a determined from satellite telemetry. *Journal of Mammalogy*, **87(5)**: 866–877.

ELWEN, S.H., BEST, P.B., REEB, D. and M. THORNTON, 2009. Near-shore diurnal movements and behaviour of Heaviside's dolphins (*Cephalorhynchus heavisidii*), with some comparative data for dusky dolphins (*Lagenorhynchus obscurus*). *South African Journal of Wildlife Research,* **39(2)**: 143-154.

ELWEN S.H., REEB D., THORNTON M. and P.B. BEST, 2009. A population estimate of Heaviside's dolphins *Cephalorhynchus heavisidii* in the southern end of their range. *Marine Mammal Science***25**: 107-124.

ELWEN S.H., SNYMAN L. and R.H. LEENEY, 2010a. Report of the Nambian Dolphin Project 2010: Ecology and consevation of coastal dolphins in Namibia. Submitted to the Ministry of Fisheries and Marine Resources, Namibia. Pp. 1-36.

ELWEN S.H., THORNTON M., REEB D. and P.B. BEST, 2010b. Near-shore distribution of Heaviside's (*Cephalorhynchus heavisidii*) and dusky dolphins (*Lagenorhynchus obscurus*) at the southern limit of their range in South Africa. *African Journal of Zoology* **45**: 78-91.

ELWEN, S.H., TONACHELLA, N., BARENDSE, J,. COLLINS, T.J.Q., BEST, P.B., ROSENBAUM, H.C., LEENEY, R.H. and T. GRIDLEY. 2014. Humpback Whales off Namibia: Occurrence, Seasonality, and a Regional Comparison of Photographic Catalogs and Scarring. Journal of Mammalogy, 95 (5): 1064–76. doi:10.1644/14-MAMM-A-108.

EMANUEL, B.P., BUSTAMANTE, R.H., BRANCH, G.M., EEKHOUT, S. and F.J. ODENDAAL, 1992. A zoogeographic and functional approach to the selection of marine reserves on the west coast of South Africa. *S. Afr. J. Mar. Sci.*, **12**: 341-354.

ESSINK, K., 1993. Ecosystem effects of dredging and dumping in the Ems-Dollard estuary and the Wadden Sea, RWS, RIKZ.

ESSINK, K., 1997. Risk analysis of coastal nourishment techniques (RIACON). Final evaluation report. Rijkswaterstaat, National Institute for Coastal and Marine Management/RIKZ.

ESSINK, K., 1999. Ecological effects of dumping of dredged sediments; options for management. *Journal ofCoastal Conservation*, **5**: 12.

FANINI, L., MARCHETTI, G.M., SCAPINI, F. & O. DEFEO, 2009. Effects of beach nourishment and groynes building on population and community descriptors of mobile arthropodofauna. *Ecological Indicators*, **9**: 167-178.

FEGLEY, S.R., MACDONALD, B.A. and T.R. JACOBSEN, 1992. Short-term variation in the quantity and quality of seston available to benthic suspension feeders. *Estuar. Coast. Shelf Sci.*, **34**: 393–412.

FIELD, J.G. and C.L. GRIFFITHS, 1991. Littoral and sublittoral ecosystems of southern Africa. In: MATHIESON, A.C. and P.H. NIENHUIS (Eds). Ecosystems of the World. 24: Intertidal and Littoral Ecosystem. Elsevier, Amsterdam. Pp. 323-346.

FIELD, J.G., GRIFFITHS, C.L., GRIFFITHS, R.J., JARMAN, N., ZOUTENDYK, P., VELIMIROV, B. and A. BOWES, 1980. Variation in structure and biomass of kelp communities along the south-west cape coast. Trans. Roy. Soc. S. Afr. 44: 145-203.

FINDLAY, K.P., 1996. The impact of diamond mining noise on marine mammal fauna off southern Namibia. Specialist Study #10. In: Environmental Impact Report. Environmental Evaluation Unit (ed.) Impacts of deep sea diamond mining, in the Atlantic 1 Mining Licence Area in Namibia, on the natural systems of the marine environment. No. 11-96-158, University of Cape Town. Report to De Beers Marine (Pty) Ltd. pp. 370

FINDLAY K.P., BEST P.B., ROSS G.J.B. and V.C. COCKROFT. 1992. The distribution of small odontocete cetaceans off the coasts of South Africa and Namibia. *S. Afr. J. Mar. Sci.* 12: 237-270.

FINDLAY, K.P., SEAKAMELA, S.M., MEŸER, M.A., KIRKMAN, S.P., BARENDSE, J., CADE, HURWITZ, D., KENNEDY, A.S., KOTZE, P.G.H., MCCUE, S.A., THORNTON, M., VARGAS-FONSECA, O.A., & C.G. WILKE, 2017. Humpback whale "super-groups" - A novel low-latitude feeding behaviour of Southern Hemisphere humpback whales (*Megaptera novaeangliae*) in the Benguela Upwelling System. PLoS ONE 12(3): e0172002. doi:10.1371/journal.pone.0172002

FOSSING, H., FERDELMAN, T.G. and P. BERG, 2000. Sulfate reduction and methane oxidation in continental margin sediments influenced by irrigation (South-East Atlantic off Namibia). *Geochim. Cosmochim. Acta.* **64(5)**: 897–910.

GOMEZ-PINA, G. MUNOZ-PEREZ, J. RAMIREZ, J.L. & C. LEY, 2002. Sand dune management problems and techniques, Spain. *Journal of Coastal Research,***36**: 325-332.

GORZELANY, J.F. & W.G. NELSON, 1987. The effects of beach replenishment on the benthos of a sub-tropical Florida beach. *Marine Environmental Research*, **21**: 75-94.

GRIFFITHS, C.L., HOCKEY, P.A.R., VAN ERKOM SCHURINK, C. and P.J.L. ROUX, 1992. Marine invasive aliens on South African shores: implications for community structure and trophic functioning. *South African Journal of marine Science***12**: 713-722.

GRIFFITHS, C.L. and J.L. SEIDERER, 1980. Rock-lobsters and mussels - limitations and preferences in a predator-prey interaction. J. *Expl Mar. Biol. Ecol.*, **44(1)**: 95-109.

HACKNEY, C.T., POSEY, M.H., ROSS, S.W. & A.R. NORRIS (eds.), 1996. A Review and Synthesis of Data: Surf Zone Fishes and Invertebrates in the South Atlantic Bight and the Potential Impacts from Beach Nourishment. Prepared for U.S. Army Corps of Engineers, Wilmington District, Wilmington, NC.

HALL, S. J. 1994. Physical disturbance and marine benthic communities: life in unconsolidated sediments. *Oceanogr. Mar. Biol. Ann. Rev.*, **32**: 179-239.

HARRIS, L.R., 2012. An ecosystem-based patial conservation plan for the South African sandy beaches. Published PhD Thesis, Nelson Mandela University, Port Elizabeth

HARVEY, M., GAUTHIER, D. and J. MUNRO, 1998. Temporal changes in the composition and abundance of the macro-benthic invertebrate communities at dredged material disposal sites in the Anse a Beaufils, Baie des Chaleurs, Eastern Canada. *Marine Pollution Bull*etin, **36**: 41-55.

HAWKINS, S.J. & R.G. HARTNOLL, 1983. Grazing of intertidal algae by marine invertebrates. *Oceanography & Marine Biology: An Annual Review*, **21**: 195-282.

HAYDEN, B. & R. DOLAN, 1974. Impact of beach nourishment on distribution of Emerita talpoida, the common mole crab. *Journal of Waterways, Harbors, and Coastal Engineering Division*, **100**: 123-132.

HAYS, G.C. HOUGHTON, J.D.R., ISAACS, C. KING, R.S. LLOYD, C. and P. LOVELL, 2004. First records of oceanic dive profiles for leatherback turtles, *Dermochelys coriacea*, indicate behavioural plasticity associated with long-distance migration. *Animal Behaviour,***67**: 733-743.

HERRMANN, C., KRAUSE, J. Chr., TSOUPIKOVA, N. and K. HANSEN, 1999. Marine Sediment extraction in the Baltic Sea. Status Report. Baltic Sea Env. Proc., 76. 29 pp.

HOCKEY, P.A.R. & A.L. BOSMAN, 1986. Man as an intertidal predator in Transkei: disturbance, community convergence and management of a natural food resource. *Oikos*, **46**: 3-14.

HOCKEY, P.A.R. and C. VAN ERKOM SCHURINK, 1992. The invasive biology of the mussel *Mytilus galloprovincialis* on the southern African coast. *Transactions of the Royal Society of South Africa***48**: 123-139.

HURME, A.K. and E.J. PULLEN, 1988. Biological effects of marine sand mining and fill placement for beach replenishment: Lessons for other uses. *Mar. Min.*, **7**: 123-136.

HUTCHINGS L., NELSON G., HORSTMANN D.A. and R. TARR, 1983. Interactions between coastal plankton and sand mussels along the Cape coast, South Africa. *In:Sandy Beaches as Ecosystems.* Mclachlan A and T E Erasmus (eds). Junk, The Hague. pp 481-500.

HYLLEBERG, J., NATEEWATHANA, A. and B. CHATANANTHAWEJ, 1985. Temporal changes in the macrobenthos on the west coast of Phuket Island, with emphasis on the effects of offshore tin mining. *Res. Bull. Phuket Mar. Biol. Center*. 38: 32 pp.

IWC, 2012. Report of the Scientific Committee. Annex H: Other Southern Hemisphere Whale Stocks Committee 11–23.

JANSSEN, G.M., LEEWIS, L. & S. MARX, 2011. Mitigation of the ecological effects of nourishment on sandy shores, a case study. In: BAYED, A. (ed.). Sandy beaches and coastal zone management – Proceedings of the Fifth International Symposium on Sandy Beaches, 19th-23rd October 2009, Rabat, Morocco *Travaux de l'Institut Scientifique, Rabat, série générale*, **6**: 121-123.

JANSSEN, G.M. & S. MULDER, 2005. Zonation of macrofauna across sandy beaches and surf zones along the Dutch coast. *Oceanologia*, **47(2)**: 265–282.

JARAMILLO, E., MCLACHLAN, A. and J. DUGAN, 1995. Total sample area and estimates of species richness in exposed sandy beaches. *Marine Ecology Progress Series***119**: 311-314.

JARMAN N.G. and R.A. CARTER, 1981. The primary producers of the inshore regions of the Benguela. *Trans. Roy. Soc. S. Afr.*, **44(3)**: 321-325.

JUTTE, P.C., R.F. VAN DOLAH & M.V. LEVISEN, 1999a. An environmental monitoring study of the Myrtle Beach Renourishment Project: Physical and biological assessment of offshore sand borrow sites - Phase I.- Cherry Grove to North Myrtle Beach. Final Report. Prepared by the Marine Resources Division, South Carolina Department of Natural Resources for U.S. Army Corps of Engineers, Charleston, S.C.

JUTTE, P.C., R.F. VAN DOLAH, & M.V. LEVISEN, 1999b. An environmental monitoring study of the Myrtle Beach Renourishment Project: Intertidal benthic community assessment of Phase II.-Myrtle Beach. Supplemental Report. Prepared by the Marine Resources Division, South Carolina Department of Natural Resources for U.S. Army Corps of Engineers, Charleston, S.C.

KENNY, A.J. and H.L. REES, 1994. The effects of marine gravel extraction on the macrobenthos: Early post-dredging recolonisation. *Mar. Poll. Bull.*, **28**: 442-447.

KENNY, A.J. and H.L. REES, 1996. The effects of marine gravel extraction on the macrobenthos: Results 2 years post-dredging. *Mar. Poll. Bull.*, **32**: 615-622.

KINOSHITA, I. and S. FUJITA, 1988. Larvae and juveniles of blue drum, *Nibea mitsukurii*, occurring in the surf zone of Tosa Bay, Japan. *Jap. J. Ichthyology*, **35**: 25-30.

KIRK, J.T.O., 1985. Effects of suspensoids on penetration of solar radiation in aquatic ecosystems. *Hydrobiologia*, **125**: 195-208.

KRANZ, P.M., 1974. The anastrophic burial of bivalves and its paleoecological significance. *Journal of Geology*, **82**:29

LAIRD, M. and C.L. GRIFFITHS, 2008. Present distribution and abundance of the introduced barnacle *Balanus glandula* Darwin in South Africa. *African Journal of Marine Science***30**: 93-100.

LAMBARDI, P., LUTJEHARMS, J.R.E., MENACCI, R., HAYS, G.C. and P. LUSCHI, 2008. Influence of ocean currents on long-distance movement of leatherback sea turtles in the Southwest Indian Ocean. *Marine Ecology Progress Series*, **353**: 289–301.

LANE, S.B. and R.A. CARTER, 1999. *Generic Environmental Management Programme for Marine Diamond MIning off the West Coast of South Africa*. Marine Diamond Mines Association, Cape Town, South Africa. 6 Volumes.

LASIAK, T.A. 1981. Nursery grounds of juvenile teleosts: evidence from surf zone of King's beach, Port Elizabeth. *S. Afr. J. Sci.*, **77**: 388-390.

LE ROY, D., DEGRAER, S., MEGAERT, K., DOBBELAERE, I., VINCX, M. & P. VANHAECKE, 1996. Risk of shoreface nourishment for the coastal marine benthic community. Evaluation of the nourishment of De Haan, Belgium. ECOLAS N.V., Antwerpen.

LEVITT, G.J., ANDERSON, R.J., BOOTHROYD, C.J.T. and F.A. KEMP, 2002. The effects of kelp harvesting on its regrowth and the understorey benthic community at Danger Point, South Africa, and a new method of harvesting kelp fronds. *South African Journal of Marine Science***24**: 71-85.

LINDQUIST, N. & L. MANNING, 2001. Impacts of Beach Nourishment and Beach Scraping on Critical Habitat and Productivity of Surf Fishes, Final Report.

LITTLER, M.M., MARTZ, D.R. & D.S. LITTLER, 1983. Effects of recurrent sand deposition on rocky intertidal organisms: importance of substrate heterogeneity in a fluctuating environment. *Marine Ecology Progress Series,***11**: 129-139.

LITTLER, M.N. & S.N. MURRAY, 1975. Impact of sewage on the distribution, abundance and community structure of rocky intertidal macro-organisms. *Marine Biology*, **30**: 277-291.

LÖFFLER M. & J. COOSEN, 1995. Ecological Impact of Sand Replenishment. P.291-299. In: HEALY & DOODY (Eds). *Directions in European Coastal Management*. Samara Publishing Ltd., Cardigan.

LOMBARD, A.T., STRAUSS, T., HARRIS, J., SINK, K., ATTWOOD, C. and HUTCHINGS, L. (2004) *National Spatial Biodiversity Assessment 2004: South African Technical Report Volume 4: Marine Component*

LUDYNIA, K., 2007. *Identification and characterisation of foraging areas of seabirds in upwelling systems: biological and hydrographic implications for foraging at sea*. PhD thesis, University of Kiel, Germany.

LYNCH, A.E., 1994. *Macrofaunal recolonization of Folly Beach, South Carolina, After Beach Nourishment*. Unpublished master’s thesis, University of Charleston, Charleston, S.C.

MAJIEDT, P., HOLNESS, S., SINK, K., OOSTHUIZEN, A. and P. CHADWICK, 2013. Systematic Marine Biodiversity Plan for the West Coast of South Africa. South African National Biodiversity Institute, Cape Town. Pp 46.

MATE, B.R., BEST, P.B., LAGERQUIST, B.A. and , M.H. WINSOR, 2011. Coastal, offshore and migratory movements of South African right whales revealed by satellite telemetry. *Marine Mammal Science*, **27(3)**: 455-476.

MATTHEWS, S.G. and G.C. PITCHER, 1996. Worst recorded marine mortality on the South African coast. In: YASUMOTO, T, OSHIMA, Y. and Y. FUKUYO (Eds), *Harmful and Toxic Algal Blooms*. Intergovernmental Oceanographic Commission of UNESCO, pp 89-92.

MAURER, D., KECK, R.T., TINSMAN, J.C. and W.A. LEATHEM, 1981a. Vertical migration and mortality of benthos in dredged material: Part I – Mollusca. *Marine Environmental Research*, **4**: 299-319.

MAURER, D., KECK, R.T., TINSMAN, J.C. and W.A. LEATHEM, 1981b. Vertical migration and mortality of benthos in dredged material: Part II – Crustacea. *Marine Environmental Research*, **5**: 301.317.

MAURER, D., KECK, R.T., TINSMAN, J.C. and W.A. LEATHEM, 1982. Vertical migration and mortality of benthos in dredged material: Part III – Polychaeta. *Marine Environmental Research*, **6**: 49-68.

MAURER, D.L., LEATHEM, W., KINNER, P. and J. TINSMAN, 1979. Seasonal fluctuations in coastal benthic invertebrate assemblages. *Estuarine and Coastal Shelf Science*, 8: 181-193.

MAURER, D., KECK, R.T., TINSMAN, J.C. and W.A. LEATHAM, 1986. Vertical migration and mortality of marine benthos in dredged material: A synthesis. *Int. Revue Ges. Hydrobiol*ogia, **71**: 49-63.

MAYFIELD, S., 1998. Assessment of predation by the West Coast rock lobster (*Jasus lalandii*): relationships among growth rate, diet and benthic community composition, with implications for the survival of juvenile abalone (*Haliotis midae*) Unpusblished PhD Thesis, University of Cape Town

MAYFIELD, S., BRANCH, G.M. and A.C. COCKCROFT, 2000. Relationships among diet, growth rate and food availability for the South African rock lobster, *Jasus lalandii*. *Crustaceana***73(7)**: 815–834.

McLACHLAN, A., 1980. The definition of sandy beaches in relation to exposure: a simple rating system. *S. Afr. J. Sci.*, **76**: 137-138.

McLACHLAN, A., 1996. Physical factors in benthic ecology: effects of changing sand particle size on beach fauna. *Marine Ecology Progress Series,***131**: 205-217.

McLACHLAN, A. and A.C. BROWN, 2006. The Ecology of Sandy Shores. Academic Press, Elsivier.

McLACHLAN, A., JARAMILLO, E., DONN, T.E. and F. WESSELS. 1993. Sandy beach macrofauna communities and their control by the physical environment: a geographical comparison. *Journal of coastal Research, Special Issue*, **15**: 27-38.

McLACHLAN, A., NEL, R., BENTLEY, A., SIMS, R. & D. SCHOEMAN, 1994. *Effects of diamond mine fine tailings on sandy beaches in the Elizabeth Bay Area, Namibia*. Contract Report, pp 1-40.

McQUAID, C.D. and G.M. BRANCH, 1985. Trophic structure of rocky intertidal communities: response to wave action and implications for energy flow. *Mar. Ecol. Prog. Ser.*, **22**: 153-161.

McQUAID, C.D. & K.M. DOWER, 1990. Enhancement of habitat heterogeneity and species richness on rocky shores inundated by sand. *Oecologia (Berlin),***84**, 142-144.

MELVILLE-SMITH, R., GOOSEN, P.C. and T.J. STEWART, 1995. The spiny lobster Jasus lalandii (H. Milne Edwards, 1837) off the South African coast: inter-annual variations in male growth and female fecundity. *Crustaceana* 68(2): 174-183

MENGE, B.A., 1992. Community regulation: under what conditions are bottom-up factors important on rocky shores? *Ecology***73**, 755-765.

MENN, I., 2002. Ecological comparison of two sandy shores with different wave energy and morphodynamics in the North Sea. *Berliner Polarforschung und Meeresforschung*, **417**: 1-174.

MENN, I., JUNGHANS, C. & K. REISE, 2003. Buried alive: Effects of beach nourishment on the infauna of an erosive shore in the North Sea. *Senckenbergiana Maritima,***32**:125-145

MILLER, D.C. and R.W. STERNBERG, 1988. Field measurements of the fluid and sediment dynamic environment of a benthic deposit feeder. *J. Mar. Res.*, **46**: 771-796.

MITCHELL-INNES, B.A. and D.R. WALKER. 1991. Short-term variability during an Anchor Station study in the southern Benguela upwelling system. Phytoplankton production and biomass in relation to species changes. *Prog. Oceanogr.*, **28**: 65-89.

MODDE, T. 1980. Growth and residency of juvenile fishes within a surf zone habitat in the Gulf of Mexico. *Gulf Research Reports*, **6**: 377-385.

MONTEIRO, P.M.S., 1998. Assessment of sediment biogeochemical characteristics in the Espirito Santo Estuary-Maputo, Bay system in order to devise a low risk dredging-disposal management plan linked to the proposed MOZAL Matola Terminal. CSIR Report No: ENV/s-C98131 A. pp 39.

MOTSIE, R., 2010. Value Chain System of South Africa's Heavy Mineral Sands Industry, 2010. Department of Mineral Resources: Directorate Mineral Economics. REPORT R84 /2010, pp27.

MULDER, S., RAADSCHELDERS, E.W. & J. CLEVERINGA, 2005. Een verkenning van de natuurbeschermingswet-geving in relatie tot Kustlijnzorg. De effecten van zandsuppleties op de ecologie van strand en onderwateroever, RWS RIKZ.

NAQVI, S.M. & E.J. PULLEN, 1982. Effects of beach nourishment and borrowing on marine organisms. *US Army Corps Engineers, Misc. Rep.*, **82-14**: 1-43.

NEL, P., 2001. Physical and biological factors structuring sandy beach macrofauna communities. PhD Thesis, University of Cape Town, Cape Town, South Africa: pp 202

NEL, R., McLACHLAN, A. & D.P.E. WINTER, 2001. The effect of grain size on the burrowing of two *Donax* species. *Journal of Experimental Marine Biology and Ecology*,**265,** 219-238.

NEL, R. and A. PULFRICH, 2002. An assessment of the impacts of beach mining operations on beach macrofaunal communities between the Sout River and Olifants River mouth. Pisces Environmental Services (Pty) Ltd. Report to Trans Hex Operations (Pty) Ltd. September 2002, 38pp.

NEL, R., PULFRICH, A. and A.J. PENNEY, 2003. Impacts of Beach Mining Operations on Sandy Beach Macrofaunal Communities on the Beaches of Geelwal Karoo. Pisces Environmental Services (Pty) Ltd. Report to Trans Hex Operations (Pty) Ltd. October 2003, 54pp.

NELSON, G., 1989. Poleward motion in the Benguela area. In: Poleward Flows along Eastern Ocean Boundaries. NESHYBA *et al.* (eds) New York; Springer: 110-130 (Coastal and Estuarine Studies 34).

NELSON G. and L. HUTCHINGS, 1983. The Benguela upwelling area. *Prog. Oceanogr.*, **12**: 333-356.

NELSON, W.G., 1985. Physical and Biological Guidelines for Beach Restoration Projects. Part I. Biological Guidelines. Report No. 76. Florida Sea Grant College, Gainesville.

NELSON, W.G., 1989. An overview of the effects of beach nourishment on the sand beach fauna. In: Proceedings of the 1988 National Conference on Beach Preservation Technology. Tallahassee: Florida Shore and Beach Preservation Association. Pp. 295-309.

NELSON, W.G. 1993. Beach restoration in the southeastern US: Environmental Effects and Biological Monitoring. *Ocean Coastal Management*, **19**: 157-182.

NEWELL, R.C., SEIDERER, L.J., SIMPSON, N.M. & J.E. ROBINSON, 2004. Impacts of Marine Aggregate Dredging on Benthic Macrofauna off the South Coast of the United Kingdom. *Journal of Coastal Research*, **20(1)**: 115–125.

NEWMAN, G.G. and D.E. POLLOCK, 1971. Biology and migration of rock lobster *Jasus lalandii* and their effect on availability at Elands Bay, South Africa. *Investl. Rep. Div. Sea Fish. S. Afr.*, **94**: 1-24.

NEWTON, D.J. and J. CHAN, 1998. South Africa's trade on southern African succulent plants. TRAFFIC East/Southern Africa, Johannesburg.

OOSTHUIZEN W.H., 1991. General movements of South African (Cape) fur seals *Arctocephalus pusillus pusillus* from analysis of recoveries of tagged animals. *S. Afr. J. Mar. Sci.*, **11**: 21-30.

O'TOOLE, M.J., 1997. A baseline environmental assessment and possible impacts of exploration and mining of diamond deposits (Prospecting Grants Areas M46/3/1946, 1950) off the coast of Namibia. In: LANE, S & CMS, 1996. Environmental Assessment and Management Plan report for deep sea diamond mining in Namibia by Arena Mining (Pty) Ltd.

PARR, T., DIENER, D. & S. LACY, 1978. Effects of Beach Replenishment on the Nearshore Sand Fauna at Imperial Beach, California. MR-78-4. U.S. Army Corps of Engineers Coastal Engineering Research Center.

PARSONS, T.R., KESSLER T.A. & L. GUANGUO, 1986a. An ecosystem model analysis of the effect of mine tailings on the euphotic zone of a pelagic ecosystem. *Acta Oceanol. Sin.*, **5**: 425-436.

PARSONS, T.R., THOMPSON, P., WU YONG, LALLI, C.M., HOU SHUMIN & XU HUAISHU, 1986b. The effect of mine tailings on the production of plankton. *Acta Oceanol. Sin.*, **5**: 417-423.

PAYNE, A.I.L. andR.J.M. CRAWFORD, 1989. *Oceans of Life off Southern Africa.* Vlaeberg, Cape Town, 380 pp.

PENNEY, A.J., PULFRICH, A., ROGERS, J., STEFFANI, N. and V. MABILLE, 2008. *Project: BEHP/CEA/03/02: Data Gathering and Gap Analysis for Assessment of Cumulative Effects of Marine Diamond Mining Activities on the BCLME Region.* Final Report to the BCLME mining and petroleum activities task group. December 2007. 410pp.

PENRY, G.S., 2010. *Biology of South African Bryde's whales.* PhD Thesis. University of St Andrews, Scotland, UK.

PETERS, I.T, BEST, P.B. & M. THORNTON, 2005. Abundance Estimates of Right Whales on a Feeding Ground off the West Coast of South Africa. Paper SC/S11/RW11. Submitted to the International Whaling Commission.

PETERSON, C.H., HICKERSON, D.H.M. and G.G. JOHNSON, 2000. Short-Term Consequences of Nourishment and Bulldozing on the Dominant Large Invertebrates of a Sandy Beach. *J. Coast. Res.*, **16(2)**: 368-378.

PETERSON, C.H. & L MANNING, 2001. How beach nourishment affects the habitat value of intertidal beach prey for surf fish and shorebirds and why uncertainty still exists. In: Proceedings of the Coastal Ecosystems & Federal Activities Technical Training Symposium, August 20-22, 2001. Gulf Shores, Alabama.

PETERSON, C.H., LANEY, W. & T. RICE, 2001. Biological impacts of beach nourishment. Workshop on the Science of Beach Renourishment, May 7-8, 2001. Pine Knoll Shores, North Carolina.

PILLAR, S.C., 1986. Temporal and spatial variations in copepod and euphausid biomass off the southern and and south-western coasts of South Africa in 1977/78. *S. Afr. J. mar. Sci.*, **4**: 219-229.

PILLAR, S.C., BARANGE, M. and L. HUTCHINGS, 1991. Influence of the frontal sydtem on the cross-shelf distribution of Euphausia lucens and Euphausia recurva (Euphausiacea) in the Southern Benguela System. *S. Afr. J. mar. Sci.*, **11** : 475-481.

PITCHER, G.C., 1998. *Harmful algal blooms of the Benguela Current*. IOC, World Bank and Sea Fisheries Research Institute Publication. 20 pp.

POOPETCH, T. 1982. Potential effects of offshore tin mining on marine ecology. Proceedings of the Working Group Meeting on environmental management in mineral resource development, Mineral Resource Development Series, 49: 70-73.

POTTER, I.C., BECKLEY, L.E., WHITFIELD, A.K. and R.C.J. LENANTON, 1990. Comparisons between the roles played by estuaries in the life cycles of fishes in temperate Western Australia and southern Africa. *Environ. Biol. of Fishes*, **28**: 143-178.

PULFRICH, A., 2004. *Baseline Survey of Sandy Beach Macrofaunal Communities at Elizabeth Bay: Beach Monitoring Report - 2004.*Prepared for NAMDEB Diamond Corporation (Pty) Ltd., Oranjemund, Namibia, on behalf of CSIR Environmentek, 53pp.

PULFRICH, A., 2016. Intertidal Rocky-Shore Communities of the Sperrgebiet Coastline: Consolidated Rocky-shores Monitoring Report – 2016. *Report to NAMDEB Diamond Corporation (Pty) Ltd., Oranjemund, Namibia*. 126pp.

PULFRICH, A., 2017. Intertidal Rocky-Shore Communities of the Sperrgebiet Coastline: Consolidated Rocky-shores Monitoring Report – 2017. *Report to NAMDEB Diamond Corporation (Pty) Ltd., Oranjemund, Namibia*. 118pp.

PULFRICH, A., 2017. Amendment of Environmental Management Programmes for Mining Rights 554MRC, 10025MRC, 512MRC and 513MRC. Marine and Coastal Ecology Assessment. Prepared for SLR Environmental Consulting (Pty) Ltd on behalf of Alexkor RMC Pooling and Sharing JV. October 2017, 196pp.

PULFRICH, A., 2018. Intertidal Rocky-Shore Communities of the Sperrgebiet Coastline: Consolidated Rocky-shores Monitoring Report – 2018. *Report to NAMDEB Diamond Corporation (Pty) Ltd., Oranjemund, Namibia*. 121pp.

PULFRICH, A., 2019. Intertidal Rocky-Shore Communities of the Sperrgebiet Coastline: Consolidated Rocky-shores Monitoring Report – 2019. *Report to NAMDEB Diamond Corporation (Pty) Ltd., Oranjemund, Namibia*..

PULFRICH, A. & L.J. ATKINSON, 2007. *Monitoring environmental effects of sediment discharges from the Uubvlei treatment plant on sandy beach and rocky intertidal biota in Mining Area 1, Namibia.* Report to NAMDEB Diamond Corporation (Pty) Ltd., Oranjemund, Namibia, September 2007, 87pp.

PULFRICH, A. & G.M. BRANCH, 2014. Effects of sediment deposition from Namibian diamond mines on intertidal and subtidal rocky-reef communities and the rock lobster *Jasus lalandii*. *Estuarine, Coastal and Shelf Science*, 150: 179-191.

PULFRICH, A. & G.M. BRANCH, 2014. Using diamond-mined sediment discharges to test the paradigms of sandy-beach ecology. *Estuarine, Coastal and Shelf Science*, 150: 165-178.

PULFRICH, A., CLARK, B.M. & K. HUTCHINGS, 2007. *Sandy Beach and Rocky Intertidal Monitoring Studies in the Bogenfels Mining Licence Area, Namibia.* Monitoring Report 2007. Report to NAMDEB Diamond Corporation (Pty) Ltd., Oranjemund, Namibia. 122pp.

PULFRICH, A., CLARK, B.M. & K. HUTCHINGS, 2008. *Survey of Sandy-Beach Macrofaunal Communities on the Sperrgebiet Coastline: Consolidated Beach Monitoring Report – 2008.* Report to NAMDEB Diamond Corporation (Pty) Ltd., Oranjemund, Namibia. 191pp.

PULFRICH, A., CLARK, B.M. & K. HUTCHINGS, 2010. Survey of Sandy-Beach Macrofaunal Communities on the Sperrgebiet Coastline: Consolidated Beach Monitoring Report – 2010. Report to NAMDEB Diamond Corporation (Pty) Ltd., Oranjemund, Namibia. 142pp.

PULFRICH, A., CLARK, B.M. & K. HUTCHINGS, 2011. Survey of Sandy-Beach Macrofaunal Communities on the Sperrgebiet Coastline: Consolidated Beach Monitoring Report – 2011. Report to NAMDEB Diamond Corporation (Pty) Ltd., Oranjemund, Namibia.

ULFRICH, A., CLARK, B.M. & K. HUTCHINGS, 2012. Survey of Sandy-Beach Macrofaunal Communities on the Sperrgebiet Coastline: Consolidated Beach Monitoring Report – 2012. *Report to NAMDEB Diamond Corporation (Pty) Ltd., Oranjemund, Namibia*. 180pp.

PULFRICH, A., CLARK, B.M., HUTCHINGS, K. & A. BICCARD, 2013. Survey of Sandy-Beach Macrofaunal Communities on the Sperrgebiet Coastline: Consolidated Beach Monitoring Report – 2013. *Report to NAMDEB Diamond Corporation (Pty) Ltd., Oranjemund, Namibia*. 191pp.

PULFRICH, A., CLARK, B.M., BICCARD, A., LAIRD, M. & K. HUTCHINGS, 2014. Survey of Sandy-Beach Macrofaunal Communities on the Sperrgebiet Coastline: Consolidated Beach Monitoring Report – 2014. *Report to NAMDEB Diamond Corporation (Pty) Ltd., Oranjemund, Namibia*. 191pp.

PULFRICH, A., HUTCHINGS, K., A. BICCARD & CLARK, B.M., 2015. Survey of Sandy-Beach Macrofaunal Communities on the Sperrgebiet Coastline: Consolidated Beach Monitoring Report – 2015. *Report to NAMDEB Diamond Corporation (Pty) Ltd., Oranjemund, Namibia*. 186pp.

PULFRICH, A. & HUTCHINGS, K., 2016. Survey of Sandy-Beach Macrofaunal Communities on the Sperrgebiet Coastline: Consolidated Beach Monitoring Report – 2016. *Report to NAMDEB Diamond Corporation (Pty) Ltd., Oranjemund, Namibia*. 132pp.

PULFRICH, A. & HUTCHINGS, K., 2017. Survey of Sandy-Beach Macrofaunal Communities on the Sperrgebiet Coastline: Consolidated Beach Monitoring Report – 2017. *Report to NAMDEB Diamond Corporation (Pty) Ltd., Oranjemund, Namibia*. 128pp.

PULFRICH, A. & HUTCHINGS, K., 2018. Survey of Sandy-Beach Macrofaunal Communities on the Sperrgebiet Coastline: Consolidated Beach Monitoring Report – 2018. *Report to NAMDEB Diamond Corporation (Pty) Ltd., Oranjemund, Namibia*. 121pp.

PULFRICH, A. & HUTCHINGS, K., 2019. Survey of Sandy-Beach Macrofaunal Communities on the Sperrgebiet Coastline: Consolidated Beach Monitoring Report – 2018. *Report to NAMDEB Diamond Corporation (Pty) Ltd., Oranjemund, Namibia*.

PULFRICH, A., NEL, P. and A.J PENNEY, 2004. Impacts of Beach Mining Operations on Sandy Beach Macrofaunal Communities on the Beaches of Geelwal Karoo: 2004 Beach Survey. Pisces Environmental Services (Pty) Ltd. Report to Trans Hex Operations (Pty) Ltd. October 2004, 42pp.

PUPIENIS, D., BUYNEVICH, I.V. and A. BITINAS, 2011. Distribution and significance of heavy-mineral concentrations along the southeast Baltic Sea coast. Journal of Coastal Research, SI 64 (Proceedings of the 11th International Coastal Symposium), 1984 – 1988. Szczecin, Poland, ISSN 0749-0208

RAKOCINSKI, C.F., HEARD, R.W., LECROY, S.E., MCLELLAND, J.A. & T. SIMONS, 1996. Responses by macrobenthic assemblages to extensive beach restoration at Perdido Key, Florida, U.S.A. *Journal of Coastal Research*, **12**: 326-353.

RAND, A.M., 2006. Using Geographic Information Systems and Remote Sensing to improve the management of kelp resources in South Africa. MSc Thesis, University of Cape Town

REILLY, F. JR. & V. BELLIS, 1978. A Study of the ecological Impact of Beach Nourishment with Dredged Material on the Intertidal Zone. East Carolina University Institute for Coastal and Marine Resources, Technical Report No. 4, Greenville, North Carolina. 107 pp.

REILLY, F., JR. & F.J. BELLIS, 1983. The ecological impact of beach nourishment with dredged materials on the intertidal zone at Bogue Banks, North Carolina. *U.S. Army Corps of Engineers, CERC Misc. Rep.* **83-3**: 1-74.

REISE, K., 1985. Tidal flat ecology. An experimental approach to species interactions. Springer Verlag, Berlin

ROBERTS, R.D., MURRAY, S., GREGORY, R. & B.A. FOSTER, 1998. Developing an efficient macrofauna monitoring index from an impact study - A dredge spoil example. *Mar. Pollut. Bull.*, **36**: 231-235.

ROBINSON, T., GRIFFITHS, C., McQUAID, C. and M. RIUS, 2005. Marine alien species of South Africa - status and impacts. *African Journal of Marine Science***27**: 297-306.

ROGERS, J. and J.M. BREMNER, 1991. The Benguela Ecosystem. Part VII. Marine-geological aspects. *Oceanogr. Mar. Biol. Ann. Rev.*, **29**: 1-85.

ROSENBAUM, H.C., POMILLA, C., MENDEZ, M., LESLIE, M.S., BEST, P.B., FINDLAY, K.P., MINTON, G., ERSTS, P.J., COLLINS, T., ENGEL, M.H., BONATTO, S., KOTZE, P.G.H., MEŸER, M., BARENDSE, J., THORNTON, M., RAZAFINDRAKOTO, Y., NGOUESSONO, S., VELY, M. and J. KISZKA, 2009. Population structure of humpback whales from their breeding grounds in the South Atlantic and IndianOceans. *PLoS One*, **4 (10)**: 1-11.

ROSENBAUM, H.C., MAXWELL, S., KERSHAW, F. and B.R. MATE, 2014. Quantifying long-range movements and potential overlap with anthropogenic activities of humpback whales in the South Atlantic Ocean. In press. *Conservation Biology*.

ROTHMAN, M.D., ANDERSON, R.J. and A.J. SMITH, 2006. The effects of harvesting of the South African kelp (*Ecklonia maxima*) on kelp population structure, growth rate and recruitment. *Journal of Applied Phycology***18**: 1-7.

ROUX, J-P., BRADY, R. & P.B. BEST, 2011. Southern right whales off Namibian and their relationship with those off South Africa. Paper SC/S11/RW16 submitted to IWC Southern Right Whale Assessment Workshop, Buenos Aires 13-16 Sept. 2011.

ROUX, J-P., BRADY, R. & P.B. BEST, 2015. Does disappearance mean extirpation? The case of right whales off Namibia. Marine Mammal Science 31(3): 1132-1152.

SARAVANAN, S. & N. CHANDRASEKAR, 2010. Monthly and seasonal variation in beach profile along the coast of Tiruchendur and Kanyakumari, Tamilnadu, India. Journal of Iberian Geology 36 (1): 39-54.

SAUER, W.H.H., PENNEY, A.J., ERASMUS, C., MANN, B.Q., BROUWER, S.L.,. LAMBERTH, S.J. and T.J. STEWART, 1997. An evaluation of attitudes and responses to monitoring and management measures for the South African boat-based linefishery. *S. Afr. J. Mar. Sci.*, **18**: 147-164.

SAUER, W.H.H. and C. ERASMUS, 1997. Evaluation of the line and net fisheries along the west coast of South Africa. Internal Report, Sea Fisheries Research Institute, Cape Town. 26pp

SCHAFFNER, L.C., 1993. *Baltimore Harbor and channels aquatic benthos investigations at the Wolf Alternate Disposal Site in lower Chesapeake Bay*. Final report prepared by the College of William and Mary and the Virginia Institute of Marine Science for the US Army Corps of Engineers, Baltimore District: pp. 120.

SCHOEMAN, D.S., McLACHLAN, A. and J.E. DUGAN, 2000. Lessons from a Disturbance Experiment in the Intertidal Zone of an Exposed Sandy Beach. *Estuar. Coast. Shelf Sci.*, **50(6)**: 869-884.

SCHRATZBERGER, M., REES, H.L. & S.E. BOYD, 2000a. Effects of simulated deposition of dredged material on structure of nematode assemblages - the role of burial. *Mar. Biol.*, **136**: 519-530.

SCHRATZBERGER, M., REES, H.L. & S.E. BOYD, 2000b. Effects of simulated deposition of dredged material on structure of nematode assemblages - the role of contamination. *Mar. Biol.*, **137**: 613-622.

SEIDERER, L.J. and R.C. NEWELL, 2000. TRANS HEX-SEACORE Mobile Dredging Platform Environmental Impact of Mining Trials at Greenbank Cove, Cornwall, U.K. July-August 2000. Marine Ecological Surveys Limited report to Transhex Group, August 2000, pp. 45.

SENGUPTA, D. & S. GHOSAL, 2017. Environmental Implications of Mining of Beach Placers for Heavy Minerals. Oceanography and Fisheries, Mini Review, 2(3): 3pp

SHANNON, L.V., 1985. The Benguela Ecosystem. Part 1. Evolution of the Benguela, physical features and processes. *Oceanogr. Mar. Biol. Ann. Rev.*, **23**: 105-182.

SHANNON, L.J., C.L. MOLONEY, A. JARRE and J.G. FIELD, 2003. Trophic flows in the southern Benguela during the 1980s and 1990s. *Journal of Marine Systems*, **39**: 83 - 116.

SHANNON, L.V. and F.P. ANDERSON, 1982. Application of satellite ocean colour imagery in the study of the Benguela Current system. *S. Afr. J. Photogrammetry, Remote Sensing and Cartography*, **13(3)**: 153-169.

SHANNON, L.V. and J.G. FIELD, 1985. Are fish stocks food-limited in the southern Benguela pelagic ecosystem ? *Mar. Ecol. Prog. Ser.*, **22(1)** : 7-19.

SHANNON L.V. and S. PILLAR, 1985. The Benguela Ecosystem III. Plankton. *Oceanography & Marine Biology: An Annual Review*, **24**: 65-170.

SHANNON, L.V. and M.J. O'TOOLE, 1998. BCLME Thematic Report 2: Integrated overview of the oceanography and environmental variability of the Benguela Current region. Unpublished BCLME Report, 58pp

SHAUGHNESSY P.D., 1979. Cape (South African) fur seal. In: Mammals in the Seas. *F.A.O. Fish. Ser.*, 5, **2**: 37-40.

SHENG, Y.P., CHEN, X. and E.A. YASSUNDA, 1994. Wave-induced sediment resuspension and mixing in shallow waters. *Coastal Engineering* : 3281-3294.

SHILLINGTON, F. A., PETERSON, W. T., HUTCHINGS, L., PROBYN, T. A., WALDRON, H. N. and J. J. AGENBAG, 1990. A cool upwelling filament off Namibia, South West Africa: Preliminary measurements of physical and biological properties. *Deep-Sea Res.*, **37 (11A)**: 1753-1772.

SHORT, A.D. and P.A. HESP, 1985. Wave, beach and dune interactions in southern Australia. *Marine Geology*, **48**: 259-284.

SICILIANO, S., DE MOURA, J.F., BARATA, P.C.R., DOS PRAZERES RODRIGUES D., MORAES ROGES, E., LAINE DE SOUZA, R., HENRIQUE OTT P. AND M. TAVARES, 2013. An unusual mortality of humpback whales in 2010 on the central-northern Rio de Janeiro coast, Brazil. Paper to International Whaling Commission SC63/SH1

SIMMONS, R.E., 2005. Declining coastal avifauna at a diamond mining site in Namibia: comparisons and causes. *Ostrich*, **76**: 97-103.

SIMON-BLECHER, N., GRANEVITZE, Z. and Y. ACHITUV, 2008. *Balanus glandula*: from North-West America to the west coast of South Africa. *African Journal of Marine Science* **30**: 85-92.

SINK, K.J., ATTWOOD, C.G., LOMBARD, A.T., GRANTHAM, H., LESLIE, R., SAMAAI, T., KERWATH, S., MAJIEDT, P., FAIRWEATHER, T., HUTCHINGS, L., VAN DER LINGEN, C., ATKINSON, L.J., WILKINSON, S., HOLNESS, S. and T. WOLF, 2011. Spatial planning to identify focus areas for offshore biodiversity protection in South Africa. Unpublished Report. Cape Town: South African National Biodiversity Institute.

SINK, K.J., VAN DER BANK, M.G., MAJIEDT, P.A., HARRIS, L.R., ATKINSON, L.J., KIRKMAN, S.P. and N. KARENYI (eds), 2019. South African National Biodiversity Assessment 2018 Technical Report Volume 4: Marine Realm. South African National Biodiversity Institute, Pretoria. South Africa.

SITE PLAN CONSULTING, 2008. Alexkor 2008 Revised Environmental Management Programme. November 2008.

SLR, 2018. Amendment of Environmental Management Programmes for Mining Rights 554MRC, 10025MR, 512MRC and 513MRC: Volume 1 – EMPR Amendment Overview.

SMIT, M.G.D., HOLTHAUS, K.I.E., TAMIS, J.E., JAK, R.G., KARMAN, C.C., KJEILEN-EILERTSEN, G., TRANNUM, H. & J. NEFF, 2006. *Threshold levels and risk functions for non-toxic sediment stressors: burial, grain size changes, and hypoxia - summary report – TNO*.

SMIT, M.G.D., HOLTHAUS, K.I.E., TRANNUM, H.C., NEFF, J.M., KJEILEN-EILERTSEN, G., JAK, R.G., SINGSAAS, I., HUIJBREGTS, M.A.J. & A.J. HENDRIKS, 2008. Species sensitivity distributions for suspended clays, sediment burial, and grain size change in the marine environment. *Environmental Toxicology and Chemistry*, **27**: 1006-1012.

SMITH, G.G and G.P. MOCKE, 2002. Interaction between breaking/broken waves and infragravity-scale phenomena to control sediment sediment suspension and transport in the surf zone. *Marine Geology*, **187**: 320-345.

SMITH, S.D.A. & M.J. RULE, 2001. The effects of dredge-spoil dumping on a shallow water soft-sediment community in the Solitary Islands Marine Park, NSW, Australia. *Mar. Pollut. Bull.*, **42**: 1040-1048.

SOARES, A.G., 2003. Sandy beach morphodynamics and macrobenthic communities in temperate, subtropical and tropical regions - a macroecological approach. PhD, University of Port Elizabeth

SOARES, A.G., McLACHLAN, A. and T.A. SCHLACHER, 1996. Disturbance effects of stranded kelp on populations of the sandy beach bivalve *Donax serra* (Röding). *Journal of Experimental Marine Biology and Ecology* **205**: 165-186.

SOARES, A.G., SCHLACHER, T.A. and A. McLACHLAN, 1997. Carbon and nitrogen exchange between sandy beach clams. *Marine Biology* **127**: 657-664.

SOUZA, J.R.B. & GUANUCA, N.M. 1994. Zonation and seasonal variation of the intertidal macrofauna of a sandy beach of Parana, Brazil. *Scienta Marina*, **59(2)**:103-111.

SPEYBROECK, J., BONTE, D., COURTENS, W., GHESKIERE, T., GROOTAERT, P., MAELFAIT, J.-P., MATHYS, M., PROVOOST, S., SABBE, K., STIENEN, E., VAN LANCKER, V., VINCX, M. & S. DEGRAER, 2004. *Studie over de impact van zandsuppleties op het ecosysteem, Ministerie van de Vlaamse Gemeenschap*. Afdeling waterwegen kust.

SPRING, K.D., 1981. A study of the spatial and temporal variation in the nearshore macrobenthic populations of the Florida east coast. Master's Thesis, Florida Institute of Technology, Melbourne, Florida, 1-67.

STEFFANI, C.N. and G.M. BRANCH, 2003a. Spatial comparisons of populations of an indigenous limpet *Scutellastra argenvillei* and an alien mussel *Mytilus galloprovincialis* along a gradient of wave energy. *African Journal of Marine Science***25**: 195-212.

STEFFANI, C.N. and G.M. BRANCH, 2003b. Temporal changes in an interaction between an indigenous limpet *Scutellastra argenvillei* and an alien mussel *Mytilus galloprovincialis*: effects of wave exposure. *African Journal of Marine Science***25**: 213-229.

STEFFANI, C.N. and G.M. BRANCH, 2005. Mechanisms and consequences of competition between an alien mussel, *Mytilus galloprovincialis*, and an indigenous limpet, *Scutellastra argenvillei*. *Journal of Experimental Marine Biology and Ecology***317**: 127-142.

STEGENGA, H., BOLTON, J.J. and R.J. ANDERSON, 1997. Seaweeds of the South African West Coast. *Contributions from the Bolus Herbarium, No. 18*. Creda Press, Cape Town. 655 pp.

SWEIJD, N., 1998. The potential of abalone (*Haliotis midae*) seeding in South Africa. Chapter from PhD Thesis, University of Cape Town, South Africa.

TAUNTON-CLARK, J., 1985. The formation, growth and decay of upwelling tongues in response to the mesoscale windfield during summer. *In*: South African Ocean Colour and Upwelling Experiment.

THOMISCH, K., BOEBEL, O', CLARK, C.W., HAGEN, W., SPIESECKE, S., ZITTERBART, D.P. and I. VAN OPZEELAND, 2016. Spatio-temporal patterns in acoustic presence and distribution of Antarctic blue whales *Balaenoptera musculus intermedia* in the Weddell Sea. doi: 10.3354/esr00739.

TRUEMAN, E.R. & A.D. ANSELL, 1969. The mechanisms of burrowing into soft substrata by marine animals. *Oceanography and Marine Biology: an Annual Review*, **7**: 315–366.

TURK, T.R. & M.J. RISK, 1981. Effects of sedimentation of infaunal invertebrate populations in Cobequid Bay, Bay of Fundy. *Can. J. Fish. Aquat. Sci.*, **38**: 642-648.

UNITED NATIONS ENVIRONMENTAL PROGRAMME (UNEP), 1995. *Global biodiversity assessment*. UNEP Nairobi: Cambridge University Press.

U.S. ARMY CORP OF ENGINEERS (USACE), 1989. Environmental Engineering for Coastal Protection: Engineer Manual EM 1110-2-1204, Washington, D.C.: U.S. Government Printing Office. Pp129.

U.S. ARMY CORP OF ENGINEERS (USACE), 2001. The New York Districts' Biological Monitoring Program for the Atlantic Coast of New Jersey, Asbury Park to Manasquan Section Beach Erosion Control Project. Final report. Waterways Experiment Station, Vicksburg, MS.

U.S. DEPARTMENT OF THE INTERIOR/ FISH AND WILDLIFE SERVICE (USDOI/FWS), 2000. Draft Fish and Wildlife Coordination Act Report, Brunswick County Beaches Project. Ecological Services Raleigh Field Office, Raleigh, North Carolina. 175 pp.

VAN DER MERWE, D. and D. VAN DER MERWE, 1991. Effects of off-road vehicles on the macrofauna of a sandy beach. *S. Afr. J. Sci.*, **87**: 210-213.

VAN DALFSEN, J.A. & K. ESSINK, 1997. Risk analysis of coastal nourishment techniques in The Netherlands. Part A. The ecological effects of shoreface nourishment off the island of Terschelling, Part B. The ecological effects of subaqueous sand extraction North of the island of Terschelling, Part C. Literature references. National Institute for Coastal and Marine Management RIKZ.

VAN DALFSEN, J.A., ESSINK, K., TOXVIG MADSEN, H., BIRKLUND, J., ROMERO, J. & M. MANZANERA, 2000. Differential response of macrozoobenthos to marine sand extraction in the North Sea and the Western Mediterranean. *ICES J. Mar. Sci.*,**57**: 1439–1445.

VAN DALFSEN, J.A. & K. ESSINK, 2001. Benthic community response to sand dredging and shoreface nourishment in Dutch coastal waters. *Senckenbergiana Maritima*, **31**: 329-332.

VAN DOLAH, R.F., MARTORE, R.M., LYNCH, A.E., LEVISEN, M.V., WENDT, P.H., WHITAKER, D.J. & W.D. ANDERSON, 1994. Final Report: Environmental Evaluation of the Folly Beach Nourishment Project. U.S. Army Corps of Engineers, Charleston District, Charleston, SC.

VAN GOSEN, B.S., FEY, D.L., SHAH, A.K., VERPLANCK, P.L. and T.M. HOEFEN, 2014. Deposit model for heavy-mineral sands in coastal environments: U.S. Geological Survey Scientific Investigations Report 2010–5070–L, 51 p., http://dx.doi.org/10.3133/sir20105070L

VAN MOORSEL, G.W.N.M. 1993. Long-term recovery of geomorphology and population development of large molluscs after gravel extraction at the Klaverbank (North Sea). Rapport Bureau Waardenburg bv, Culemborg, The Netherlands.

VAN MOORSEL, G.W.N.M. 1994. The Klaver Bank (North Sea), geomorphology, macrobenthic ecology and the effect of gravel extraction. Rapport Bureau Waardenburg and North Sea Directorate (DNZ), Ministry of Transport, Public Works & Water Management, The Netherlands.

VELIMIROV, B., FIELD, J.G., GRIFFITHS, C.L. and P. ZOUTENDYK, 1977. The ecology of kelp bed communities in the Benguela upwelling system. *Helgoländer Meeresunters*, **30**: 495-518.

VINDING, K. BESTER, M., KIRKMAN, S.P., CHIVELL, W. & S.H. ELWEN, 2015. The use of data from a platform of opportunity (whale watching) to study coastal cetaceans on the Southwest Coast of South Africa. Tourism in Marine Environments, 11(1) : 33-54.

VISSER, G.A., 1969. Analysis of Atlantic waters off the coast of southern Africa. *Investigational Report Division of Sea Fisheries, South Africa*, 75: 26 pp.

WARD, L.G., 1985. The influence of wind waves and tidal currents on sediment resuspension in Middle Chesapeake Bay. *Geo-Mar. Letters*, **5**: 1-75.

WALKER, D.R. and W.T. PETERSON, 1991. Relationships between hydrography, phytoplankton production, biomass, cell size and species composition, and copepod production in the southern Benguela upwelling system in April 1988. *S. Afr. J. mar. Sci.*, **11**: 289-306

WEIR, C.R., 2011. Distribution and seasonality of cetaceans in tropical waters between Angola and the Gulf of Guinea. *African Journal of Marine Science***33(1)**: 1-15.

WEIR, C.R., COLLINS, T., CARVALHO, I. and H.C. ROSENBAUM, 2010. Killer whales (*Orcinus orca*) in Angolan and Gulf of Guinea waters, tropical West Africa. *Journal of the Marine Biological Association of the U.K.* **90**: 1601– 1611.

WICKENS, P., 1994. Interactions between South African Fur Seals and the Purse-Seine Fishery. *Marine Mammal Science*, **10**: 442–457.

WSP COASTAL AND PORT ENGINEERS, 2015. Coastal Protection for beach mining in the Koingnaas Area. Report to West Coast Resources, August 2015, 50pp.

ZEEMAN, S.C.F., 2016. Genetics and ecosystem effects of the invasive mussel Semimytilus algosus, on the West Coast of South Africa. Unpublished MSc Thesis, University of Cape Town, pp253.

ZOUTENDYK, P., 1992. Turbid water in the Elizabeth Bay region: A review of the relevant literature. CSIR Report EMAS-I 92004.

ZOUTENDYK, P., 1995. Turbid water literature review: a supplement to the 1992 Elizabeth Bay Study. CSIR Report EMAS-I 95008.

APPENDIX A

Curriculum Vitae Dr Andrea Pulfrich

Personal Details

Born:	Pretoria, South Africa on 11 August 1961
Nationality and Citizenship:	South African and German
Languages:	English, German, Afrikaans
ID No:	610811 0179 087

Address:	20 Plein Street, McGregor, 6708, South Africa PO Box 302, McGregor, 6708, South Africa
Tel:	+27 21 782 9553
Cell :	082 781 8152
E-mail:	apulfrich@pisces.co.za

Academic Qualifications

BSc (Zoology and Botany), University of Natal, Pietermaritzburg, 1982
BSc (Hons) (Zoology), University of Cape Town, 1983
MSc (Zoology), University of Cape Town, 1987
PhD, Department of Fisheries Biology of the Institute for Marine Science at the Christian-Albrechts University, Kiel, Germany, 1995

Membership in Professional Societies

South African Council for Natural Scientific Professions (Pr.Sci.Nat. No: 400327/06)
South African Institute of Ecologists and Environmental Scientists
International Association of Impact Assessment (South Africa)

Employment History and Professional Experience

1998-present: Director: Pisces Environmental Services (Pty) Ltd. Specifically responsible for environmental impact assessments, baseline and monitoring studies, marine specialist studies, and environmental management plan reports.

1999: Senior researcher on contract to Namdeb Diamond Corporation and De Beers Marine South Africa, at the University of Cape Town; investigating and monitoring the impact of diamond mining on the marine environment and fisheries resources; experimental design and implementation of dive surveys; collaboration with fishermen and diamond divers; deep water benthic sampling, sample analysis and macrobenthos identification.

1996-1999: Senior researcher at the University of Cape Town, on contract to the Chief Director: Marine and Coastal Management (South African Department of Environment Affairs and Tourism); investigating and monitoring the experimental fishery for periwinkles on the Cape south coast; experimental design and implementation of dive surveys for stock assessments; collaboration with fishermen; supervision of Honours and Masters students.

1989-1994: Institute for Marine Science at the Christian-Albrechts University of Kiel, Germany; research assistant in a 5 year project to investigate the population dynamics of mussels and cockles in the Schleswig-Holstein Wadden Sea National Park (employment for

Doctoral degree); extensive and intensive dredge sampling for stock assessments, collaboration with and mediation between, commercial fishermen and National Park authorities, co-operative interaction with colleagues working in the Dutch and Danish Wadden Sea, supervision of Honours and Masters projects and student assistants, diving and underwater scientific photography. Scope of doctoral study: experimental design and implementation of a regular sampling program including: (i) plankton sampling and identification of lamellibranch larvae, (ii) reproductive biology and condition indices of mussel populations, (iii) collection of mussel spat on artificial collectors and natural substrates, (iv) sampling of recruits to the established populations, (v) determination of small-scale recruitment patterns, and (vi) data analysis and modelling. Courses and practicals attended as partial fulfilment of the degree: Aquaculture, Stock Assessment and Fisheries Biology, Marine Chemistry, and Physical and Regional Oceanography.

1988-1989: Australian Institute of Marine Science; volunteer research assistant and diver; implementation and maintenance of field experiments, underwater scientific photography, digitizing and analysis of stereo-photoquadrats, larval culture, analysis of gut contents of fishes and invertebrates, carbon analysis.

1985-1987: Sea Fisheries Research Institute of the South African Department of Environment Affairs and Tourism: scientific diver on deep diving surveys off Cape Agulhas; censusing fish populations, collection of benthic species for reef characterization.

South African National Research Institute of Oceanography and Port Elizabeth Museum: technical assistant and research diver; quantitative sampling of benthos in Mossel Bay, and census of fish populations in the Tsitsikamma National Park.

University of Cape Town, Department of Zoology and Percy Fitzpatrick Institute of African Ornithology; research assistant; supervisor of diving survey and collection of marine invertebrates, Prince Edward Islands.

1984-1986: University of Cape Town, Department of Zoology; research assistant (employment for MSc Degree) and demonstrator of first year Biological Science courses. Scope of MSc study: the biology, ecology and fishery of the western Cape linefish species *Pachymetopon blochii*, including (i) socio-economic survey of the fishery and relevant fishing communities, (ii) collection and analysis of data on stomach contents, reproductive biology, age and growth, (iii) analysis of size-frequency and catch statistics, (iv) underwater census, (v) determination of hook size selectivity, (vi) review of historical literature and (vii) recommendations to the Sea Fisheries Research Institute of the South African Department of Environment Affairs and Tourism for the modification of existing management policies for the hottentot fishery.

APPENDIX D-2:

ECOLOGY IMPACT ASSESSMENT (AWAITING INPUT)

APPENDIX D-3:

HERITAGE IMPACT INFORMATION

CTS HERITAGE

HERITAGE SCREENER

CTS Reference Number:	**CTS20_036**
Client:	**PHS**
Date:	**March 2020**
Title:	**Proposed Mining Application by Whale Head Minerals for a portion of remainder of Farm 1, Port Nolloth**

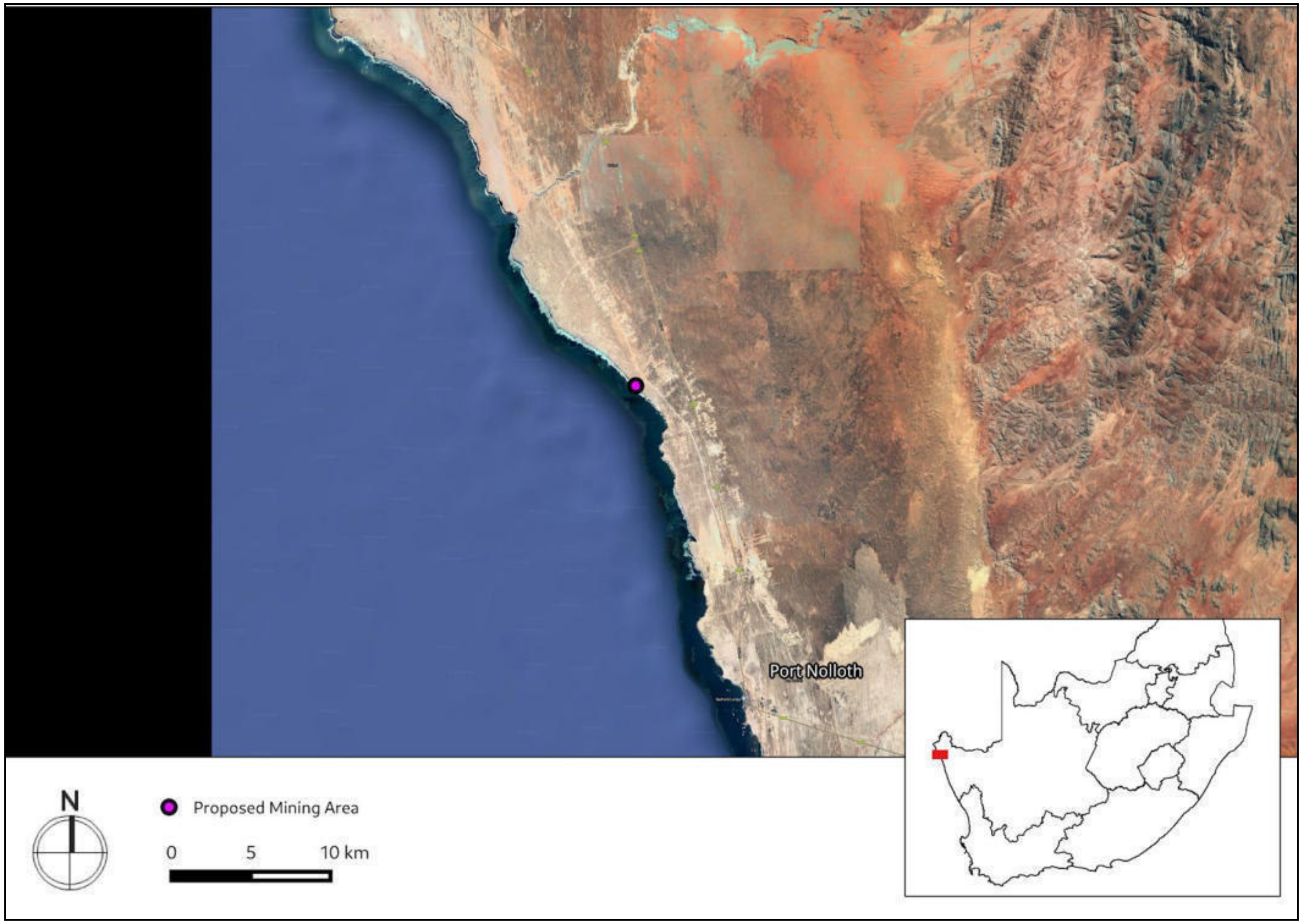


Figure 1a. Satellite map indicating the location of the proposed development in the Northern Cape Province

Recommendation by CTS Heritage Specialists	**RECOMMENDATION:** **Based on the information available, it is unlikely that significant intact archaeological resources remain on the site and as such, it is unlikely that the proposed mining activities will impact significant archaeological heritage. Furthermore it is recommended that, while no further palaeontological specialist studies are required, the attached Fossil Finds Procedure be implemented for the proposed mining activities due to the sensitivity of the fossils that may be impacted by this proposed mining activity.**

CTS Heritage
16 Edison Way, Century City, 7441
Tel: +27 (0)87 073 5739 **Email:** info@ctsheritage.com **Web:** www.ctsheritage.com

CTS HERITAGE

1. Proposed Development Summary

Whale Head Minerals (Pty) Ltd has identified a mineral sand deposit some 30 km North of Port Nolloth, Northern Cape Province, South Africa, with the aim of developing this resource to produce a saleable heavy mineral concentrate product from the wet concentrator plant (WCP), which would include garnet, ilmenite, monazite, zircon and rutile. Most of the proposed mining area falls below the high water mark. The resource was originally prospected by Alexkor in the 1980's and 1990's while exploring for diamonds. Whale Head Minerals (Pty) Ltd conducted a Feasibility Study based on the findings by Alexkor, which considered the viability of the overall project, allowing for a mining operation, with a WCP. The proposed project site is characterized by coastal environmental sensitivity, as well as the relative remoteness of the site. Fresh water is not readily available, in addition the nearest electrical power source is some kilometres from the site.

2. Application References

Name of relevant heritage authority(s)	SAHRA
Name of decision making authority(s)	DMR

3. Property Information

Latitude / Longitude	29° 4'32.10"S 16°47'55.72"E
Erf number / Farm number	Remainder of Farm 1 (majority of the area is below the high water mark of the coast)
Local Municipality	Richtersveld
District Municipality	Namakwa
Previous Magisterial District	Namakwaland
Province	Northern Cape
Current Use	Vacant/Surf Zone part of larger mining concession
Current Zoning	Mining Area
Total Extent of Property	5ha

4. Nature of the Proposed Development

Total Surface Area of development	5ha
Depth of excavation (m)	5m
Height of development (m)	NA

5. Category of Development

x	**Triggers: Section 38(8) of the National Heritage Resources Act**
	Triggers: Section 38(1) of the National Heritage Resources Act
	1. Construction of a road, wall, powerline, pipeline, canal or other similar form of linear development or barrier over 300m in length.
	2. Construction of a bridge or similar structure exceeding 50m in length.
	3. Any development or activity that will change the character of a site-
	a) exceeding 5 000m^2 in extent
	b) involving three or more existing erven or subdivisions thereof
	c) involving three or more erven or divisions thereof which have been consolidated within the past five years
	4. Rezoning of a site exceeding 10 000m^2
	5. Other (state):

6. Additional Infrastructure Required for this Development

1. ROM Stockpile Gantry incorporating 2 cyclone discharges.
2. WCP modular construction inclusive of stair modules and screen and rougher bin modules.
3. Cyclones mounted on jib arms for the high grade, low grade and bagging shed.
4. ROM feed bin and feed conveyor.
5. Bagging plant.
6. MCC support platform.
7. Workshop and Storage shed

CTS HERITAGE

7. Mapping (please see Appendix 3 and 4 for a full description of our methodology and map legends)

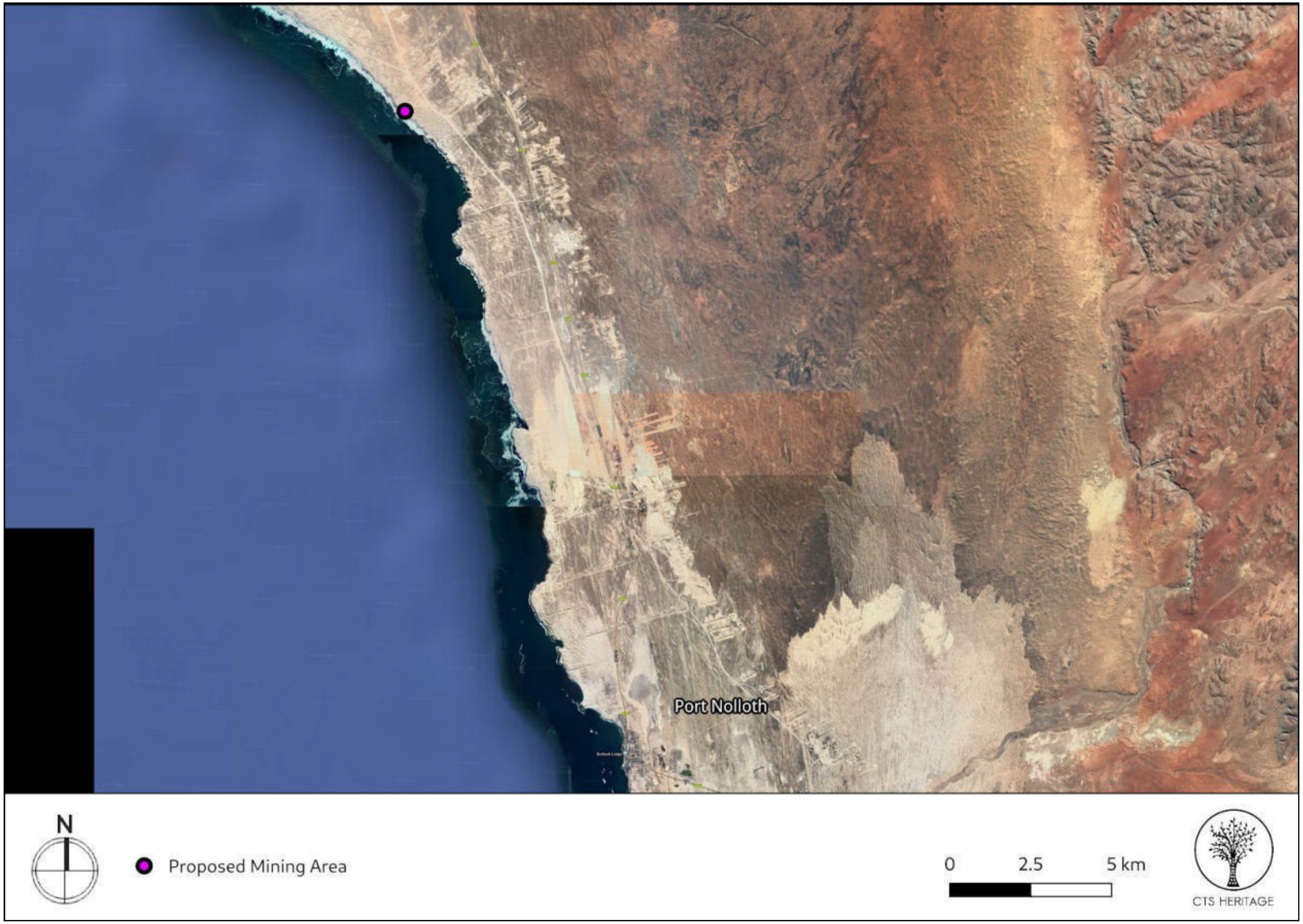


Figure 1b Overview Map. Satellite image (2019) indicating the proposed development area at closer range.

Figure 1c. Overview Map. Satellite image (2019) indicating the proposed development area at closer range.

Figure 1d. Overview Map. Satellite image (2019) indicating the proposed development area at closer range.

CTS HERITAGE

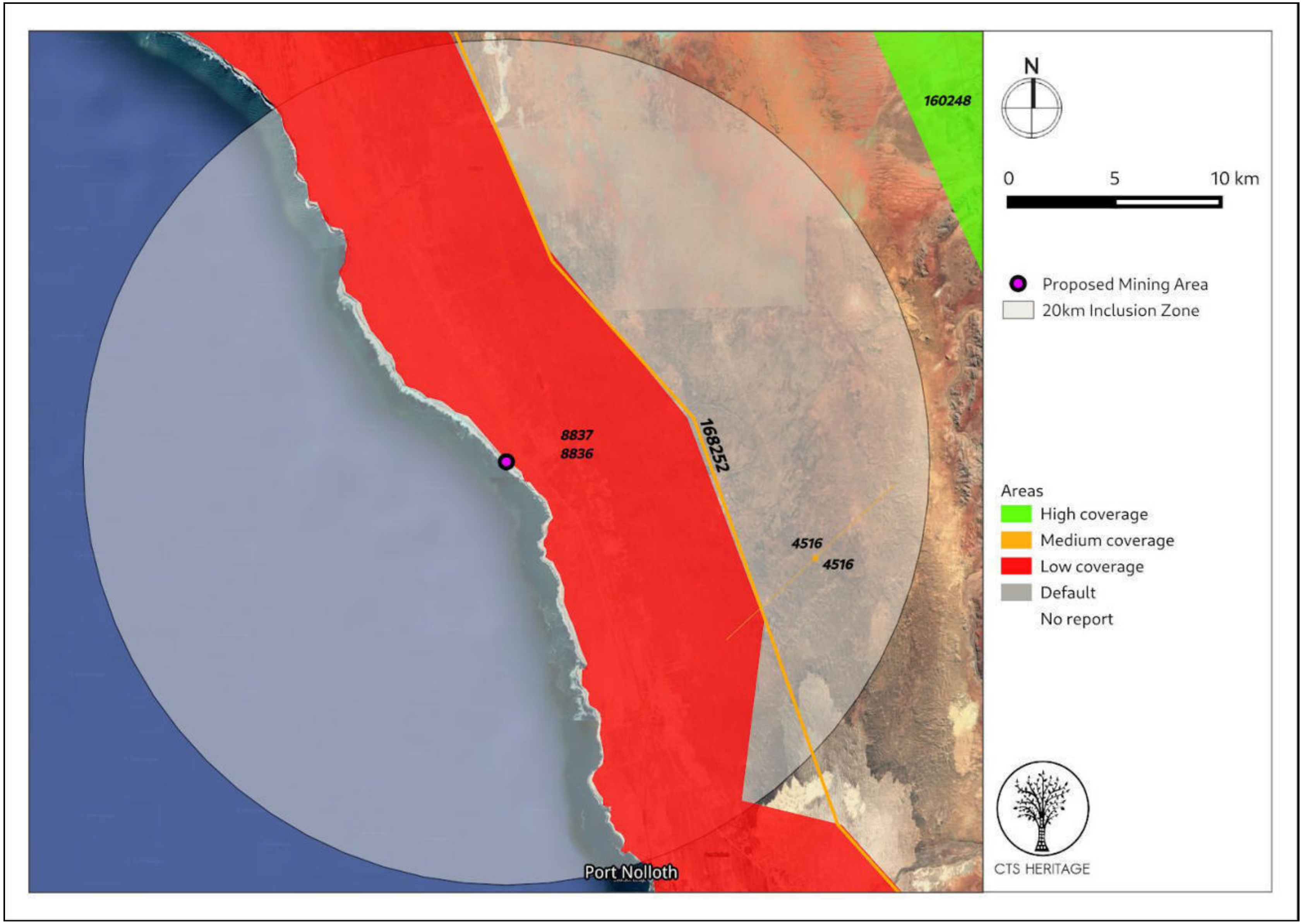


Figure 2a. Previous HIAs Map. Previous Heritage Impact Assessments surrounding the proposed development area within 5km, with SAHRIS NIDS indicated. Please see Appendix 2 for full reference list.

CTS HERITAGE

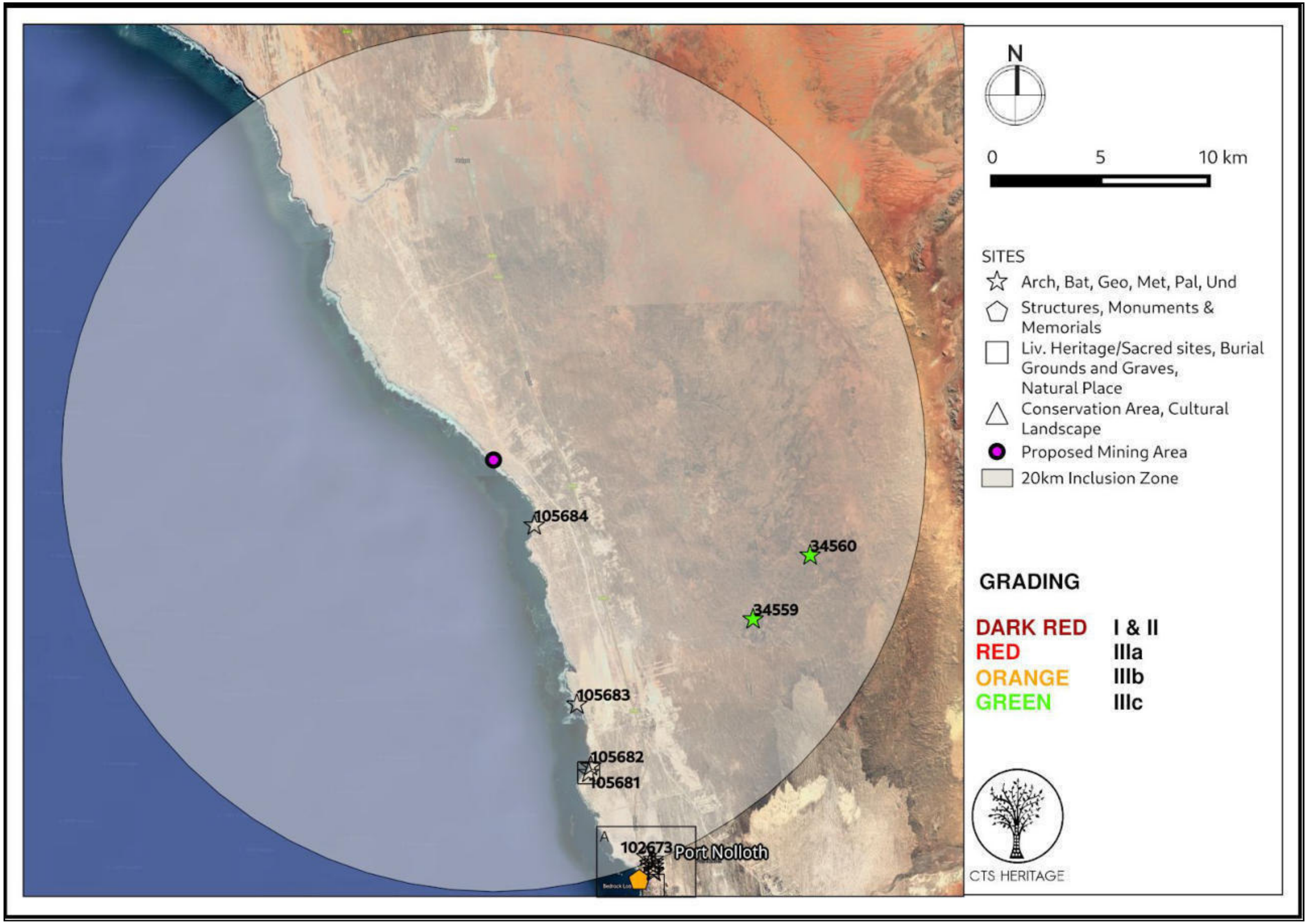


Figure 3. Heritage Resources Map. Heritage Resources previously identified in and near the study area, with SAHRIS Site IDs indicated. Please See Appendix 4 for full description of heritage resource types.

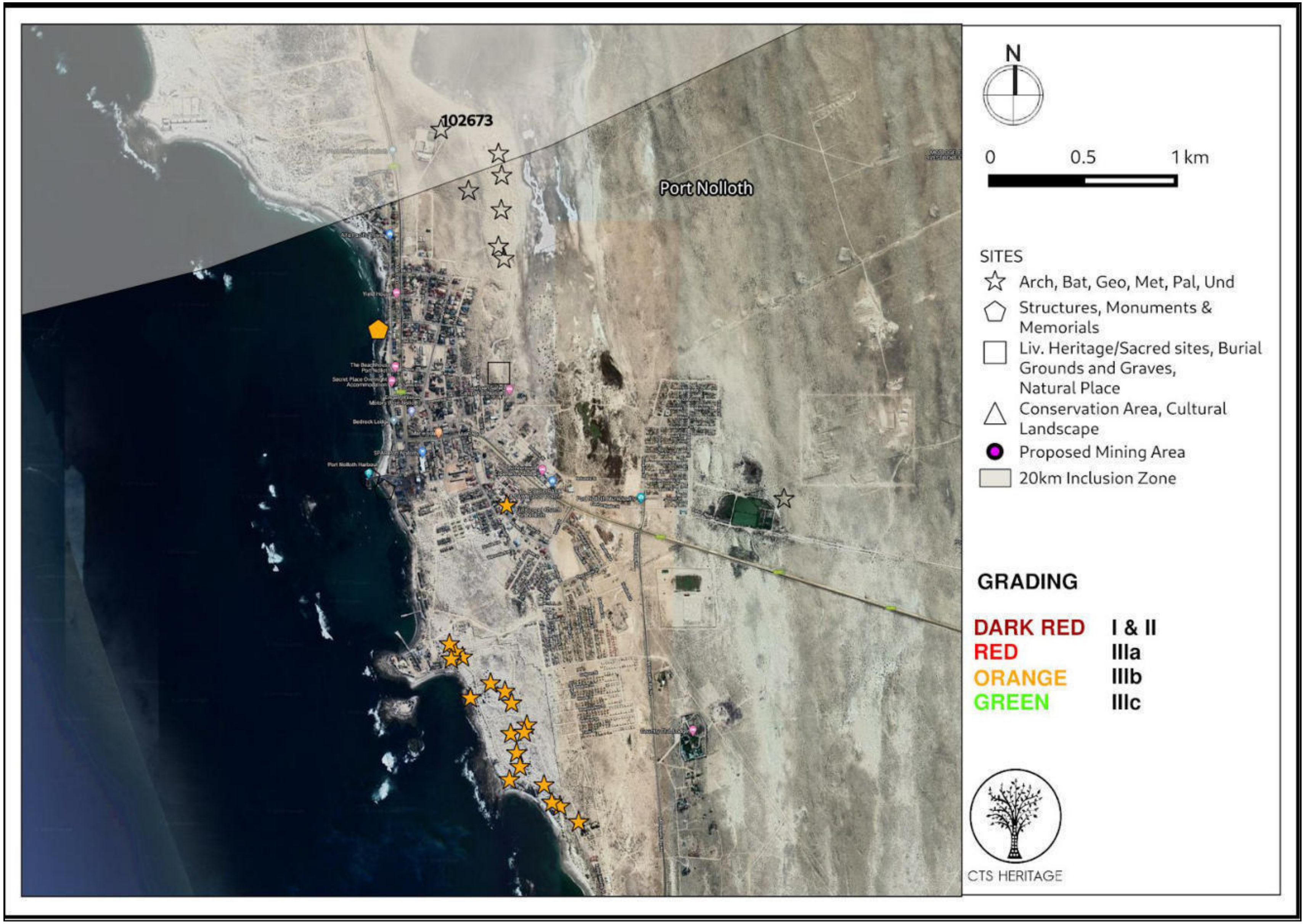


Figure 3a. Heritage Resources Map. Heritage Resources Inset A

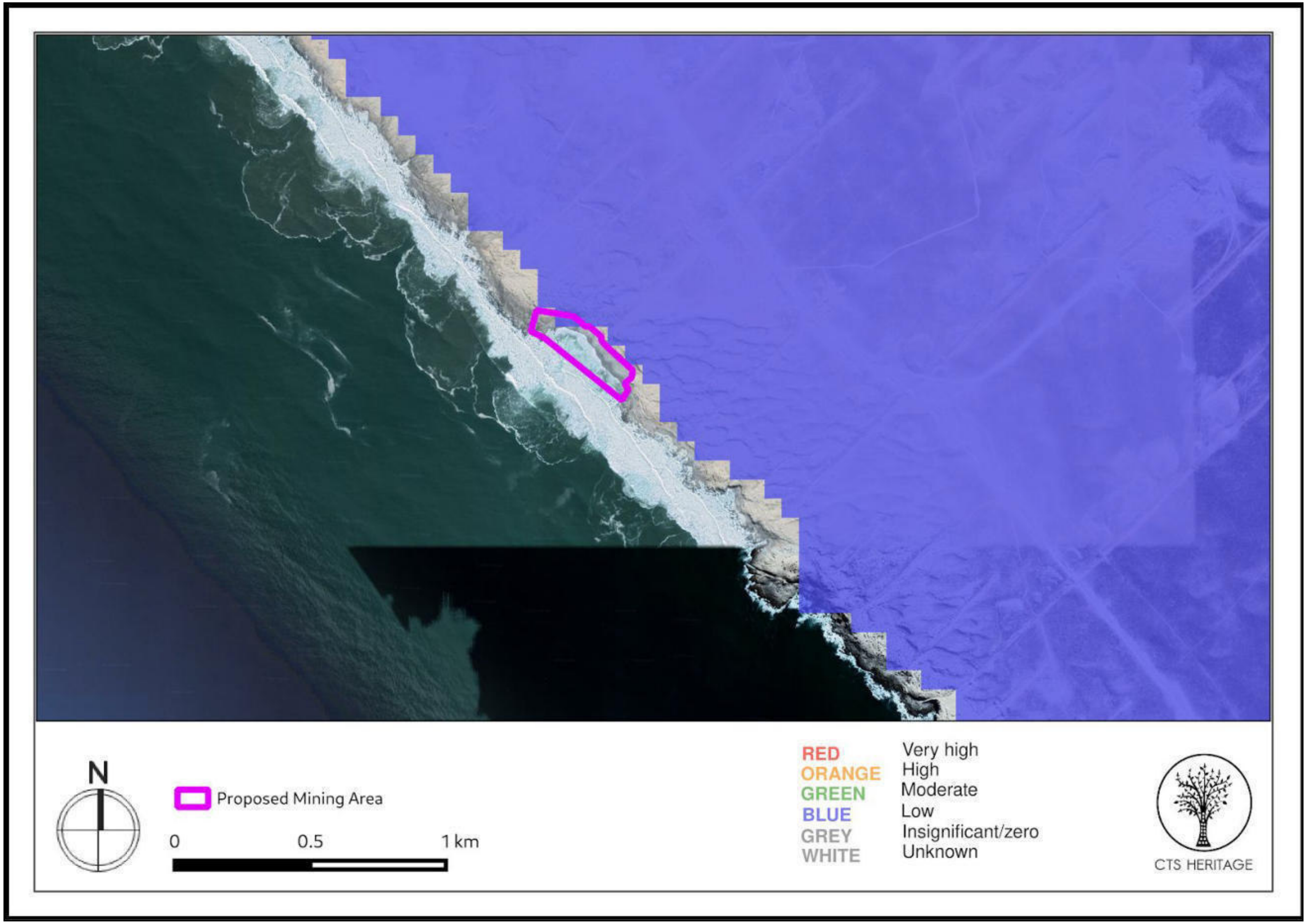


Figure 4. Palaeosensitivity Map. Indicating Low fossil sensitivity underlying the study area. Please See Appendix 3 for full guide to the legend.

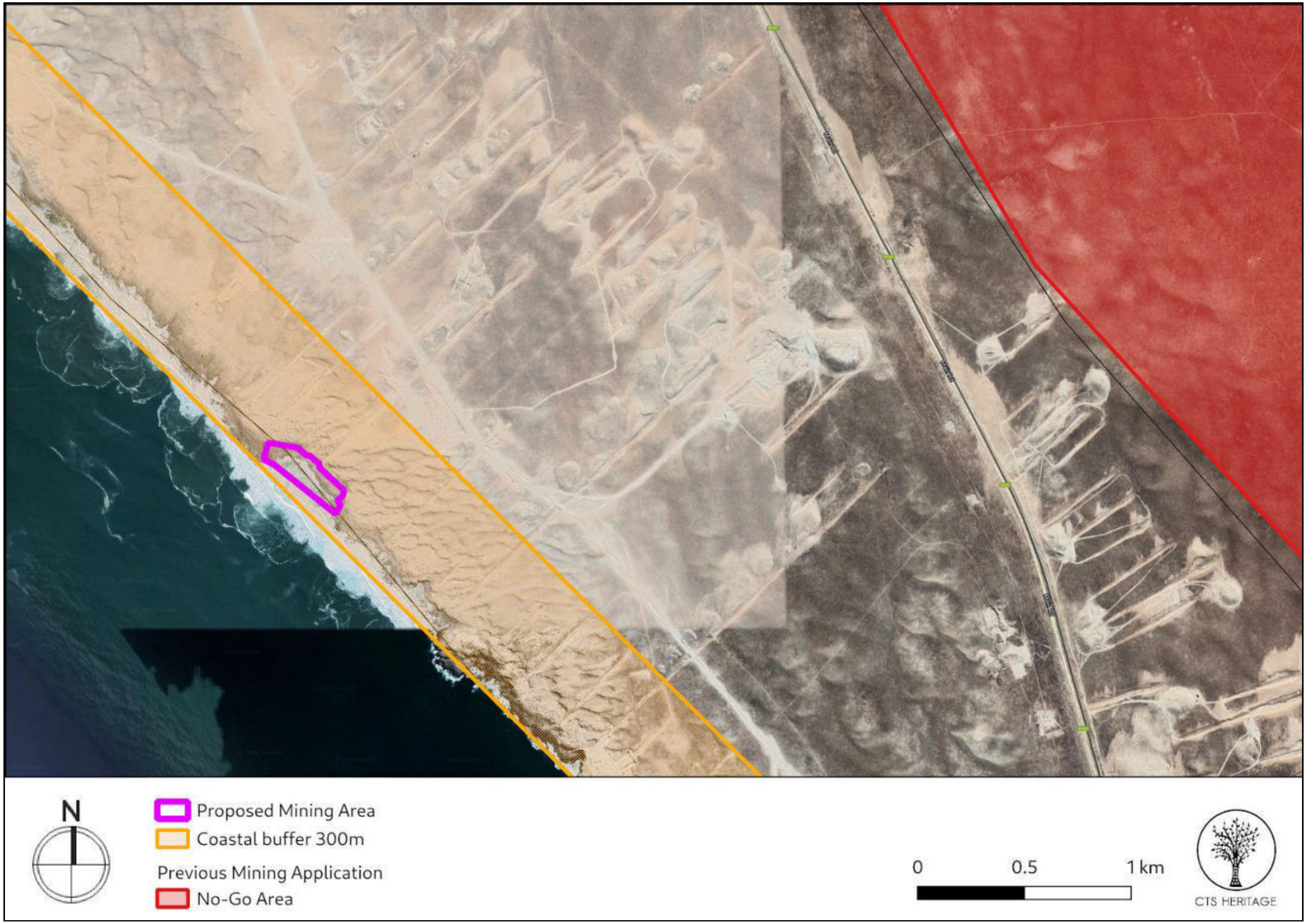


Figure 5. No-Go and High Sensitivity Areas Map. Identified in previous assessments

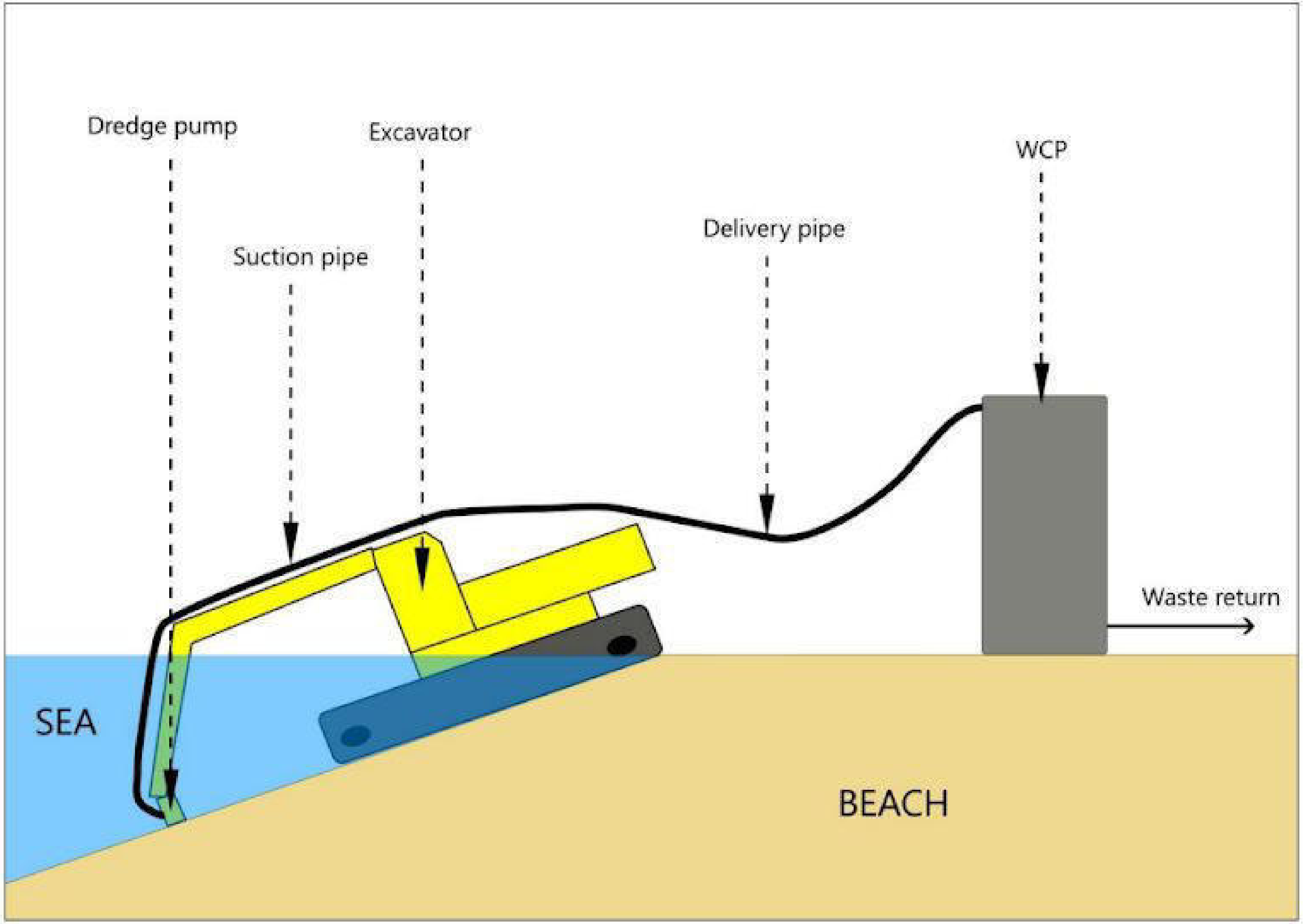


Figure 6. Mining methodology. From the Mine Works Program

Figure 7.1. Mining area 2003 and Figure 7.2 Mining area 2013 (GoogleEarth)

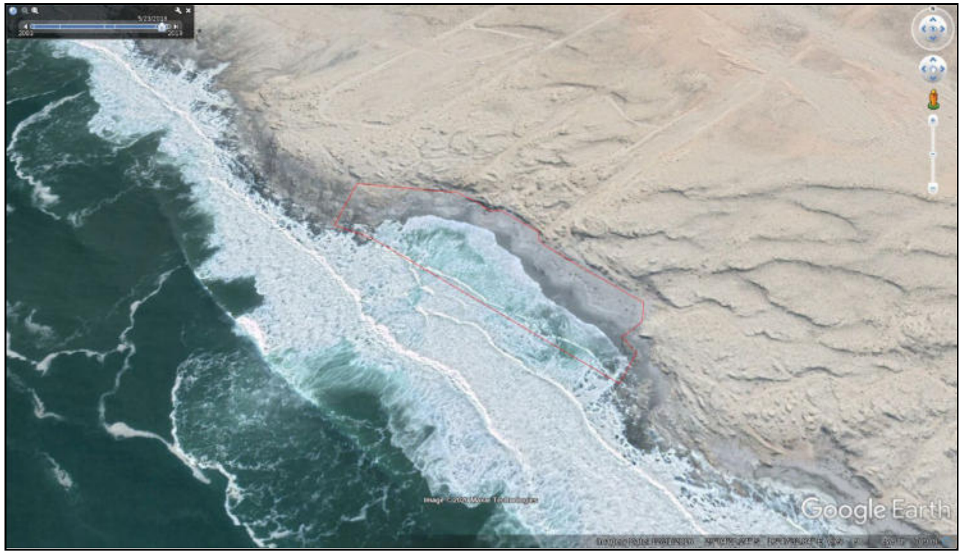


Figure 7.3. Mining area 2017 and Figure 7.4 Mining area 2018 (GoogleEarth)

8. Heritage statement and character of the area

The area proposed for mining activities is located approximately 20km north of Port Nolloth along the West Coast of South Africa. The mining method proposed will require heavy piping and equipment on the beach. Local miners who have mined diamonds for many years in the same area are of the opinion that mobility of equipment on the beach is essential so that the equipment can be removed relatively quickly and easily in the event of the sea turning. Mining at Walviskop is done by means of a high-performance suction pump which is fitted to the excavator and receives the sediment from the suction head (mining tool fitted on the end of the boom) and delivers the sediment mined from the sea bed to the 260t per hour wet concentrator plant located on the beach for gravel processing. The mining rate has been estimated at a rate of 260 tonnes per hour based on applying a non-conventional mining method to the project.

Most of the area proposed for sand mining is located below the high water mark within the active surf zone and as such, is unlikely to contain significant archaeological or palaeontological heritage. Archaeological evidence points to occupation of the West Coast region of South Africa, including the Namakwa coast from the Early Stone Age, through to the Middle and Later Stone Age, up until the arrival of early Trekboers in the 18th century (Kaplan 2008, NID 390540). The rocky shoreline attracted hunter-gatherers during the Holocene, in particular, resulting in rich archaeological deposits in the form of shell middens that stretch along the coastline and within the adjacent dune belt. In the past 2 000 years, early herders began arriving in the area, introducing livestock and new material culture (Orton 2012). Unmarked human burials occur, but these are seldom found by archaeologists, and are more commonly unearthed by mining operations (Kaplan 2008). As discussed in Smuts (2017), known heritage resources are predominantly located in undisturbed areas, except where these are structures within towns. The implications of this are twofold. Firstly, this makes it less likely that significant heritage resources will be impacted by the proposed mining, but also that sites are still present in undisturbed areas, and that these areas should therefore be avoided. However, previously, Kaplan (2008) and others (Smuts, 2017) have noted that the majority of significant heritage resources along this coastline exist within 300m of the high-water mark and as such, the areas within 300m of the high water mark have been red-flagged as particularly sensitive for impacts to significant archaeology. Most of the proposed mining activities take place within the high water mark, or just above it and as such, fall directly into this High Sensitivity Area (Figure 5). Previous recommendations required only hand-augering within this sensitive 300m buffer area.

However, this area has been subjected to ongoing mining for almost a century (see attached letter from Hattingh, 2020). Alexkor SOC Limited (“Alexkor”) a state-owned diamond mining company has been actively mining diamonds since 1928. During the period 1928 to 2018, diamonds weighing more than 10,2 million carats have been recovered from marine gravel deposits on beaches and marine terraces at the Alexkor Mine. The Walviskop area is no exception and has seen active mining with surf zone mining taking place on an ongoing basis in this area since 2004 by mainly beach based dredging operations and to a lesser extent dredge mining from small boats in the bay itself. Beach mining using heavy earth moving equipment has taken place during at least two mining campaigns since 2013. Evidence of this is clear in the GoogleEarth images from 2013 and 2018 (Figure 7.2 and 7.4). As such, any significant archaeological resources within the proposed development area are likely to have been extensively disturbed in the past. Therefore the recommended hand-augering in this area is unlikely to mitigate impacts to significant archaeological heritage resources.

According to the SAHRIS Palaeosensitivity Map, the area proposed for prospecting is underlain by Geological formations of low significance (Figure 4). The formations of low palaeontological significance include surficial Alluvium including Dune Beach Sand, the Oranjemund FM, the Holgat FM, the Vredefontein FM and Aeolianites. According to the Fossil Heritage Browser on SAHRIS, fossil bone finds during research on the Northern Cape coast mines have enabled age estimations based on correlations with the African vertebrate biochronology. Fossil data associated with the aeolian record overlaps with the presence of hominids at Elandsfontein, Duinefontein and Swartklip archaeological sites, making these very significant findings. In the marine deposits, fossil molluscan seashells, brachiopods, crustaceans (barnacles, crabs, prawns, ostracods), echinoids, polychaete worm tubes, corals, bryozoans and foraminifera are found. Shark teeth are common, and other fish teeth are known to occur, as are the bones of whales, dolphins, seals and seabirds. Pether (2007) and (2013) has written much about the palaeontological sensitivity of this area of the coastline. As such, it is recommended that, while no further palaeontological specialist studies are required, the attached Fossil Finds Procedure be implemented for the proposed mining activities due to the sensitivity of the fossils that may be impacted by this proposed mining activity.

RECOMMENDATION:
Based on the information available, it is unlikely that significant intact archaeological resources remain on the site and as such, it is unlikely that the proposed mining activities will impact significant archaeological heritage. Furthermore it is recommended that, while no further palaeontological specialist studies are required, the attached Fossil Finds Procedure be implemented for the proposed mining activities due to the sensitivity of the fossils that may be impacted by this proposed mining activity.

APPENDIX 1

List of heritage resources within the 5km Inclusion Zone from SAHRIS

Site ID	Site no	Full Site Name	Site Type	Grading
105684	ALEXKOR 11	Alexkor Diamond Mine 11	Shell Midden, Artefacts	
105683	ALEXKOR 12	Alexkor Diamond Mine 12	Shell Midden	
105682	ALEXKOR 10	Alexkor Diamond Mine 10	Shell Midden	
105681	ALEXKOR 09	Alexkor Diamond Mine 09	Burial Grounds & Graves, Shell Midden	
34560	MUI002	Muisvlak 002	Artefacts	Grade IIIc
34559	MUI001	Muisvlak 001	Artefacts	Grade IIIc
102673	PN2009/007	Port Nolloth sites	Archaeological	

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APPENDIX 2

Reference List from SAHRIS

HIAs				
SAHRIS NIDs	**Report Type**	**Author**	**Date**	**Title**
8837	PIA Phase 1	John Pether	28/09/2007	Palaeontological Heritage Impact Assessment and Mitigation Approaches
8836	PIA Phase 1	John Pether	01/11/2007	Coastal Plain Deposits of Namaqualand: Historical Palaeontology and Stratigraphy
4516	AIA Phase 1	Dave Halkett	01/01/1999	An Archaeological Assessment of Power Line Routes Between Muisvlak and Eksteenfontein, Richtersveld
168252	Heritage Impact Assessment Specialist Reports	Chrispen Chauke	31/05/2014	HERITAGE IMPACT ASSESSMENT STUDIES FOR THE PROPOSED GROMIS ORANJEMUND RECONDUCTORING, Namaqualand Region, Richtersveld Local Municipality, Northern Cape

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APPENDIX 3 - Keys/Guides

Key/Guide to Acronyms

AIA	Archaeological Impact Assessment
DARD	Department of Agriculture and Rural Development (KwaZulu-Natal)
DEA	Department of Environmental Affairs (National)
DEADP	Department of Environmental Affairs and Development Planning (Western Cape)
DEDEAT	Department of Economic Development, Environmental Affairs and Tourism (Eastern Cape)
DEDECT	Department of Economic Development, Environment, Conservation and Tourism (North West)
DEDT	Department of Economic Development and Tourism (Mpumalanga)
DEDTEA	Department of economic Development, Tourism and Environmental Affairs (Free State)
DENC	Department of Environment and Nature Conservation (Northern Cape)
DMR	Department of Mineral Resources (National)
GDARD	Gauteng Department of Agriculture and Rural Development (Gauteng)
HIA	Heritage Impact Assessment
LEDET	Department of Economic Development, Environment and Tourism (Limpopo)
MPRDA	Mineral and Petroleum Resources Development Act, no 28 of 2002
NEMA	National Environmental Management Act, no 107 of 1998
NHRA	National Heritage Resources Act, no 25 of 1999
PIA	Palaeontological Impact Assessment
SAHRA	South African Heritage Resources Agency
SAHRIS	South African Heritage Resources Information System
VIA	Visual Impact Assessment

Full guide to Palaeosensitivity Map legend

	RED:	VERY HIGH - field assessment and protocol for finds is required
	ORANGE/YELLOW:	HIGH - desktop study is required and based on the outcome of the desktop study, a field assessment is likely
	GREEN:	MODERATE - desktop study is required
	BLUE/PURPLE:	LOW - no palaeontological studies are required however a protocol for chance finds is required
	GREY:	INSIGNIFICANT/ZERO - no palaeontological studies are required
	WHITE/CLEAR:	UNKNOWN - these areas will require a minimum of a desktop study.

CTS HERITAGE

APPENDIX 4 - Methodology

The Heritage Screener summarises the heritage impact assessments and studies previously undertaken within the area of the proposed development and its surroundings. Heritage resources identified in these reports are assessed by our team during the screening process.

The heritage resources will be described both in terms of **type**:

- Group 1: Archaeological, Underwater, Palaeontological and Geological sites, Meteorites, and Battlefields
- Group 2: Structures, Monuments and Memorials
- Group 3: Burial Grounds and Graves, Living Heritage, Sacred and Natural sites
- Group 4: Cultural Landscapes, Conservation Areas and Scenic routes

and **significance** (Grade I, II, IIIa, b or c, ungraded), as determined by the author of the original heritage impact assessment report or by formal grading and/or protection by the heritage authorities.

Sites identified and mapped during research projects will also be considered.

DETERMINATION OF THE EXTENT OF THE INCLUSION ZONE TO BE TAKEN INTO CONSIDERATION

The extent of the inclusion zone to be considered for the Heritage Screener will be determined by CTS based on:

- the size of the development,
- the number and outcome of previous surveys existing in the area
- the potential cumulative impact of the application.

The inclusion zone will be considered as the region within a maximum distance of 50 km from the boundary of the proposed development.

DETERMINATION OF THE PALAEONTOLOGICAL SENSITIVITY

The possible impact of the proposed development on palaeontological resources is gauged by:

- reviewing the fossil sensitivity maps available on the South African Heritage Resources Information System (SAHRIS)
- considering the nature of the proposed development
- when available, taking information provided by the applicant related to the geological background of the area into account

DETERMINATION OF THE COVERAGE RATING ASCRIBED TO A REPORT POLYGON

Each report assessed for the compilation of the Heritage Screener is colour-coded according to the level of coverage accomplished. The extent of the surveyed coverage is labeled in three categories, namely low, medium and high. In most instances the extent of the map corresponds to the extent of the development for which the specific report was undertaken.

Low coverage will be used for:

- desktop studies where no field assessment of the area was undertaken;
- reports where the sites are listed and described but no GPS coordinates were provided.
- older reports with GPS coordinates with low accuracy ratings;
- reports where the entire property was mapped, but only a small/limited area was surveyed.
- uploads on the National Inventory which are not properly mapped.

Medium coverage will be used for

- reports for which a field survey was undertaken but the area was not extensively covered. This may apply to instances where some impediments did not allow for full coverage such as thick vegetation, etc.
- reports for which the entire property was mapped, but only a specific area was surveyed thoroughly. This is differentiated from low ratings listed above when these surveys cover up to around 50% of the property.

High coverage will be used for

- reports where the area highlighted in the map was extensively surveyed as shown by the GPS track coordinates. This category will also apply to permit reports.

RECOMMENDATION GUIDE

The Heritage Screener includes a set of recommendations to the applicant based on whether an impact on heritage resources is anticipated. One of three possible recommendations is formulated:

(1) The heritage resources in the area proposed for development are sufficiently recorded - The surveys undertaken in the area adequately captured the heritage resources. There are no known sites which require mitigation or management plans. No further heritage work is recommended for the proposed development.

This recommendation is made when:

- enough work has been undertaken in the area
- it is the professional opinion of CTS that the area has already been assessed adequately from a heritage perspective for the type of development proposed

(2) The heritage resources and the area proposed for development are only partially recorded - The surveys undertaken in the area have not adequately captured the heritage resources and/or there are sites which require mitigation or management plans. Further specific heritage work is recommended for the proposed development.

This recommendation is made in instances in which there are already some studies undertaken in the area and/or in the adjacent area for the proposed development. Further studies in a limited HIA may include:

- improvement on some components of the heritage assessments already undertaken, for instance with a renewed field survey and/or with a specific specialist for the type of heritage resources expected in the area
- compilation of a report for a component of a heritage impact assessment not already undertaken in the area

- undertaking mitigation measures requested in previous assessments/records of decision.

(3) The heritage resources within the area proposed for the development have not been adequately surveyed yet - Few or no surveys have been undertaken in the area proposed for development. A full Heritage Impact Assessment with a detailed field component is recommended for the proposed development.

Note:
The responsibility for generating a response detailing the requirements for the development lies with the heritage authority. However, since the methodology utilised for the compilation of the Heritage Screeners is thorough and consistent, contradictory outcomes to the recommendations made by CTS should rarely occur. Should a discrepancy arise, CTS will immediately take up the matter with the heritage authority to clarify the dispute.

The compilation of the Heritage Screener will not include any field assessment. The Heritage Screener will be submitted to the applicant within 24 hours from receipt of full payment. **If the 24-hour deadline is not met by CTS, the applicant will be refunded in full.**

13 March 2020

PHS Consulting
PO Box 1752
Hermanus 7200

Attention: Paul Slabbert

Historic Mining at the Walviskop Beach Area

Mr Slabbert

With reference to the status of the Walviskop area in terms of historic disturbances I can state that this area has been subjected to ongoing mining for almost a century. Alexkor SOC Limited ("Alexkor") a state-owned diamond mining company has been actively mining diamonds since 1928. During the period 1928 to 2018, diamonds weighing more than 10,2 million carats have been recovered from marine gravel deposits on beaches and marine terraces at the Alexkor Mine.

Alexkor has a mining lease to mine diamonds on land and in sea concession areas 1a, 1b, 1c, 2a, 3a, 4a, 4b and 9d as well as the adjacent surf zone areas. In the early years land-based mining at Alexkor was the main activity which was done mainly by means of dry strip mining where the overburden sand was removed to expose the diamond-bearing basal gravels. Mining progressed in time to include the beaches, surf zone and shallow to mid-water offshore areas.

In 2002 Alexkor adopted a new mining model whereby it terminated its own mining operations and started making use of contract miners. Approximately 25 different shallow water contractors are currently undertaking diver-based mining in the sub tidal concession areas. Pumps are used by both boat based operations and beach based shallow water teams to suck gravel off the sea floor and following initial screening, the gravel is processed further at the onshore dense media separation plants. In addition some 10 Beach Mining contractors and 10 Land Mining contractors are responsible for mining diamonds from the beaches and on elevated marine terraces using large earthmoving equipment.

The Contractors and Alexkor share the proceeds of the diamonds recovered from the Alexkor Lease Area on a percentage basis. Alexkor acknowledges that the contractors mining activities are critical to the stabilisation of the job creation in the Namaqualand region and their continuous employment is encouraged.

The Walviskop area is no exception and has seen active mining with surf zone mining taking place on an ongoing basis in this area since 2004 by mainly beach based dredging operations and to a lesser extent dredge mining from small boats in the bay itself.

(Reg No. 1999/05565/07)
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Beach mining using heavy earth moving equipment has taken place during at least two mining campaigns since 2013.

Evidence of this mining can be found on the Alexkor mine surveyor's maps where onshore mining excavations are meticulously recorded for submission to the DMR on a quarterly basis. Offshore mining is also recorded and archived by the marine division at Alexkor. In addition to this satellite images unmistakably show mining activities at the Walviskop beach during early 2013 and again early to mid 2018. This can also be seen on the 8/3/2013 and 23/5/2018 Google Earth images.

I trust this will give a better insight into historic activities at Walviskop beach.

Yours sincerely

Dr Johan Hattingh
PhD Geology, SACNASP

CHANCE FINDS OF PALAEONTOLOGICAL MATERIAL

(Adopted from the HWC Chance Fossils Finds Procedure: June 2016)

Introduction

This document is aimed to inform workmen and foremen working on a construction and/or mining site. It describes the procedure to follow in instances of accidental discovery of palaeontological material (please see attached poster with descriptions of palaeontological material) during construction/mining activities. This protocol does not apply to resources already identified under an assessment undertaken under s. 38 of the National Heritage Resources Act (no 25 of 1999).

Fossils are rare and irreplaceable. Fossils tell us about the environmental conditions that existed in a specific geographical area millions of years ago. As heritage resources that inform us of the history of a place, fossils are public property that the State is required to manage and conserve on behalf of all the citizens of South Africa. Fossils are therefore protected by the National Heritage Resources Act and are the property of the State. Ideally, a qualified person should be responsible for the recovery of fossils noticed during construction/mining to ensure that all relevant contextual information is recorded.

Heritage Authorities often rely on workmen and foremen to report finds, and thereby contribute to our knowledge of South Africa's past and contribute to its conservation for future generations.

Training

Workmen and foremen need to be trained in the procedure to follow in instances of accidental discovery of fossil material, in a similar way to the Health and Safety protocol. A brief introduction to the process to follow in the event of possible accidental discovery of fossils should be conducted by the designated Environmental Control Officer (ECO) for the project, or the foreman or site agent in the absence of the ECO It is recommended that copies of the attached poster and procedure are printed out and displayed at the site office so that workmen may familiarise themselves with them and are thereby prepared in the event that accidental discovery of fossil material takes place.

Actions to be taken

One person in the staff must be identified and appointed as responsible for the implementation of the attached protocol in instances of accidental fossil discovery and must report to the ECO or site agent. If the ECO or site agent is not present on site, then the responsible person on site should follow the protocol correctly in order to not jeopardize the conservation and well-being of the fossil material.

Once a workman notices possible fossil material, he/she should report this to the ECO or site agent.Procedure to follow if it is likely that the material identified is a fossil:

- The ECO or site agent must ensure that all work ceases immediately in the vicinity of the area where the fossil or fossils have been found;
- The ECO or site agent must inform SAHRA of the find immediately. This information must include photographs of the findings and GPS co-ordinates;
- The ECO or site agent must compile a Preliminary Report and fill in the attached Fossil Discoveries: Preliminary Record Form within 24 hours without removing the fossil from its original position. The Preliminary Report records basic information about the find including:
    - The date
    - A description of the discovery
    - A description of the fossil and its context (e.g. position and depth of find)
    - Where and how the find has been stored
    - Photographs to accompany the preliminary report (the more the better):
        - A scale must be used
        - Photos of location from several angles
        - Photos of vertical section should be provided
        - Digital images of hole showing vertical section (side);
        - Digital images of fossil or fossils.

Upon receipt of this Preliminary Report, SAHRA will inform the ECO or site agent whether or not a rescue excavation or rescue collection by a palaeontologist is necessary.

- Exposed finds must be stabilised where they are unstable and the site capped, e.g. with a plastic sheet or sand bags. This protection should allow for the later excavation of the finds with due scientific care and diligence. SAHRA can advise on the most appropriate method for stabilisation.
- If the find cannot be stabilised, the fossil may be collect with extreme care by the ECO or the site agent and put aside and protected until SAHRA advises on further action. Finds collected in this way must be safely and securely stored in tissue paper and an appropriate box. Care must be taken to remove the all fossil material and any breakage of fossil material must be avoided at all costs.

No work may continue in the vicinity of the find until SAHRA has indicated, in writing, that it is appropriate to proceed.

CTS HERITAGE

FOSSIL DISCOVERIES: PRELIMINARY RECORDING FORM		
Name of project:		
Name of fossil location:		
Date of discovery:		
Description of situation in which the fossil was found:		
Description of context in which the fossil was found:		
Description and condition of fossil identified:		
GPS coordinates:	*Lat:*	*Long:*
If no co-ordinates available then please describe the location:		
Time of discovery:		
Depth of find in hole		
Photographs (tick as appropriate and indicate number of the photograph)	*Digital image of vertical section (side)*	
	Fossil from different angles	
	Wider context of the find	
Temporary storage (where it is located and how it is conserved)		
Person identifying the fossil Name:		
Contact:		
Recorder Name:		
Contact:		
Photographer Name:		
Contact:		

APPENDIX E:

PUBLIC PARTICIPATION INFORMATION

(NOT AVAILABLE)

APPENDIX F:

SITE MAP

Whale Head Minerals (PTY) LTD

PLAN PREPARED IN ACCORDANCE WITH
REGULATION 2.2
OF THE REGULATIONS PUBLISHED UNDER
THE MINING TITLES REGISTRATION ACT
(ACT16 OF 1967)

APPLICATION FOR A
MINING PERMIT
OVER THE AREA LETTERED
A B C D E F G H I J K L M N O
IN EXTENT 4,98 HA
SITUARED OVER PORTION 0 (REMAINDER EXTENT)
OF FARM NO. 1

Administrative District Namaqualand
Northern Cape Province

SURVEY SYSTEM WG 17°
WGS 84 Hartebeeshoek 94
CO-ORDINATES

Name	Y (m)	X (m)
A	19831.20	3217441.12
B	19852.61	3217518.61
C	19803.14	3217542.71
D	19515.48	3217771.48
E	19492.55	3217731.90
F	19505.74	3217708.84
G	19480.98	3217689.32
H	19475.58	3217661.86
I	19583.99	3217562.75
J	19592.45	3217551.35
K	19590.89	3217539.09
L	19637.97	3217500.07
M	19652.70	3217499.77
N	19665.73	3217485.46
O	19696.01	3217463.08

PLAN APPROVED:

REGIONAL MANAGER NORTHERN CAPE

SIGNED:

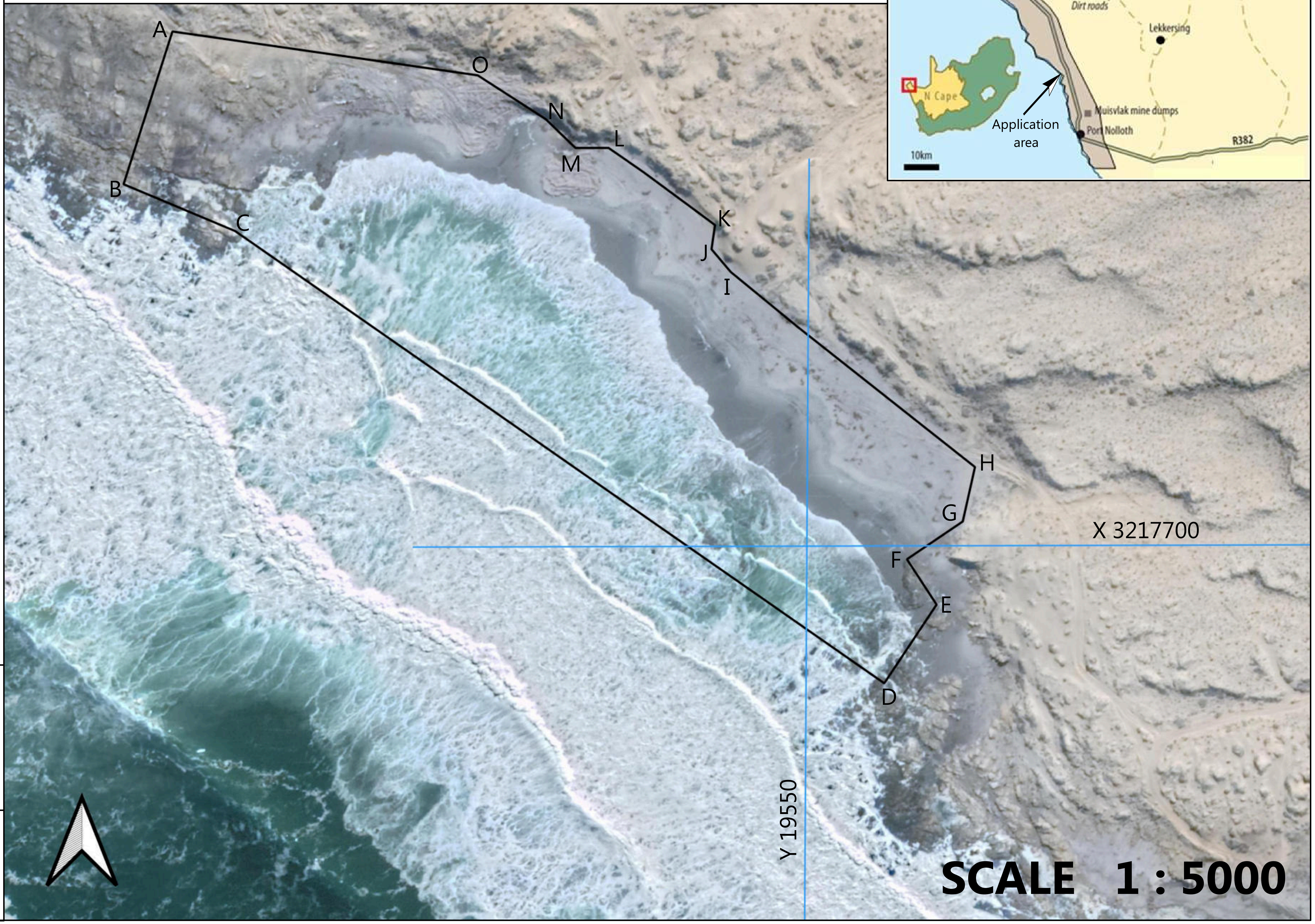
DATE:

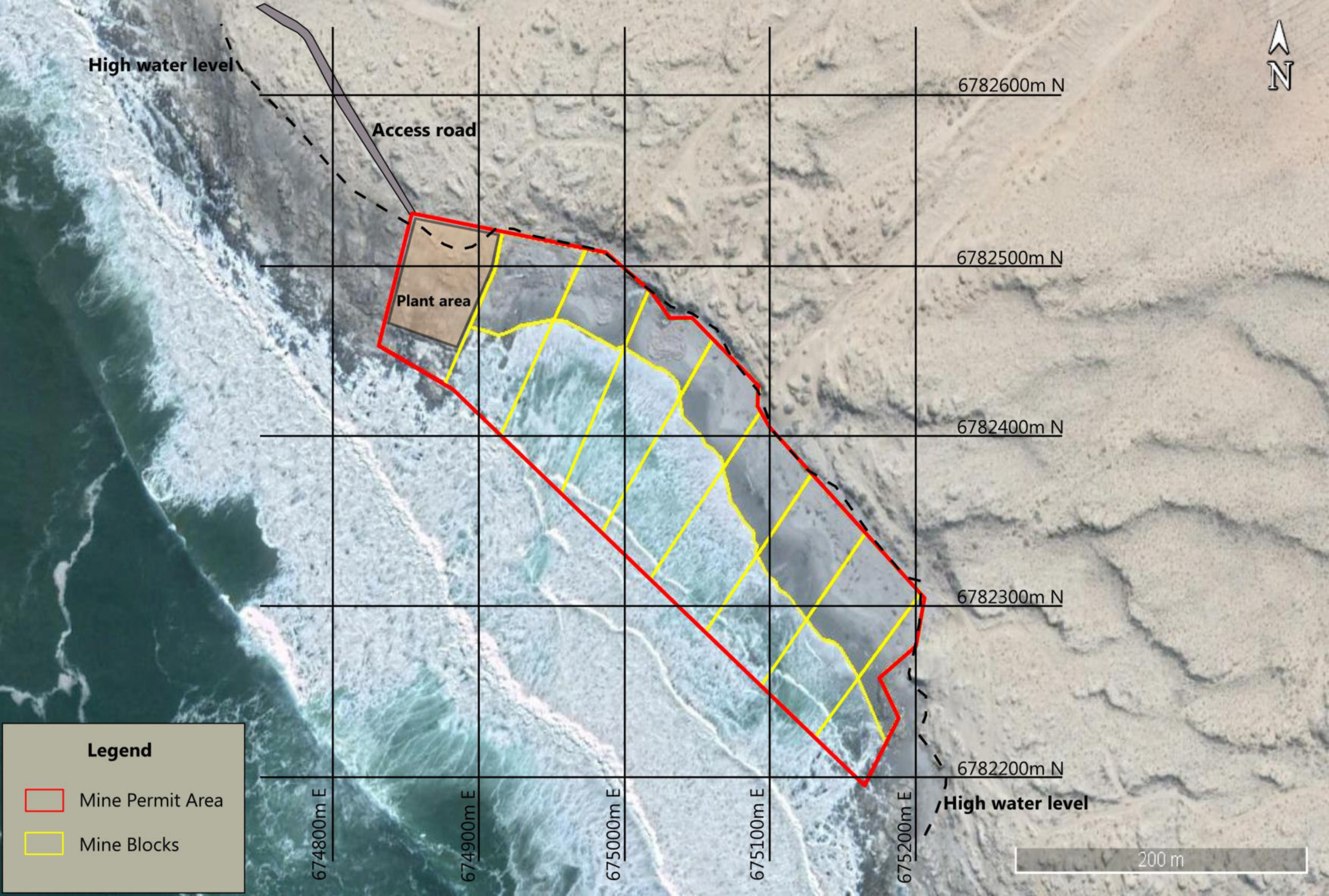
NAME OF APPLICANT:

SIGNED:

DATE:

MPT NUMBER:





High water level
Access road
Plant area
6782600m N
6782500m N
6782400m N
6782300m N
6782200m N
674800m E
674900m E
675000m E
675100m E
675200m E
High water level
N
200 m
Legend
Mine Permit Area
Mine Blocks

APPENDIX G:

MINING WORKS PROGRAMME

Mine Work Programme

for the mining of the heavy mineral sand resource at Walviskop, Port Nolloth

1. Introduction

Whale Head Minerals (Pty) Ltd has identified a mineral sand deposit some 30 km North of Port Nolloth, Northern Cape Province, South Africa, with the aim of developing this resource to produce a saleable heavy mineral concentrate product from the wet concentrator plant (WCP), which would include garnet, ilmenite, monazite, zircon and rutile. The resource was originally prospected by Alexkor in the 1980's and 1990's while exploring for diamonds. Whale Head Minerals (Pty) Ltd conducted a Feasibility Study based on the findings by Alexkor, which considered the viability of the overall project, allowing for a mining operation, with a WCP.

The operation is required to produce a garnet, ilmenite, monazite, rutile and zircon rich concentrate. The proposed project site is characterized by coastal environmental sensitivity, as well as the relative remoteness of the site. Fresh water is not readily available, in addition the nearest electrical power source is some kilometres from the site.

2. Scope of work

2.1. Beach mining

2.1.1. Introduction

The Whale Head Minerals (Pty) Ltd heavy mineral sands project is located on the West Coast of South Africa some 30 km north of Port Nolloth at a small pocket beach. Here the mineral sands are located on a narrow corridor of beach between the tidal zone and a rocky cliff line. It is estimated that approximately 622 700t of ore will be mined from the beach over a 5-year period, producing high grade heavy minerals concentrates. This timeline may be extended due to the possibility of unrealized potential in the resource through the replenishment of the resource. The replenishment takes place by heavy minerals resupply from beyond the breaker zone in the seaward part of the nearshore-midwater area as well as replenishment of heavy minerals by the longshore drift and counter current flow feeding sediment from neighbouring areas into the Walviskop bay area. Log spiral flow in the bay entrains light sand (quartz, shell fragments) and selectively deposits heavy minerals in the bay. The resource would be exploited through the use of pumping techniques whereby the ore would be pumped from the mining blocks to a wet concentrator plant.

The West Coast of South Africa is synonymous with rough and unpredictable seas which may present a risk to the project. The mining method proposed will require heavy piping and equipment on the beach. Local miners who have mined diamonds for many years in the same area are of the opinion that mobility of equipment on the beach is essential so that the equipment can be removed relatively quickly and easily in the event of the sea turning. Mining at Walviskop is done by means of a high-performance suction pump which is fitted to an excavator and receives the sediment from the suction head (mining tool fitted on the end of the excavator boom) and delivers the sediment mined from the sea bed to a ~220t per hour wet concentrator plant located on the beach for heavy mineral processing.

2.1.2 Setting

2.1.2.1 Climate

An arid climate prevails along the Southern African West Coast region. The Alexander Bay – Port Nolloth area experiences winter rainfall, albeit extremely low. From September to April, the prevailing south-westerly winds reach gale force velocities at times in excess of 70km/h, producing swells up to a maximum height of 10m.

2.1.2.2 Topography

The coastal topography just south of the Orange River mouth is generally flat across a ~5 to 10km wide stretch of sandy coastal lowland, which terminates to the east against the mountain land of the Namaqualand Metamorphic Complex. The rugged quartzite and sandstone coastline exhibit sandy pocket beaches within embayment's flanked by rocky stretches that can be continuous for several kilometres. Walviskop is a south-west facing pocket beach in one of the embayment's south of the Orange River mouth.

2.1.2.3 Water Depth

Water depth at Walviskop ranges between ~1m low tide and ~4.5m low tide in the surf zone. Seabed slope averages at 0.01.

2.1.2.4 Sea State

Average shallow marine wave height along the West Coast of South Africa is ~2.5 metres (breaking wave height exceeds 2.5 metres ~50% of the time). This is taking into account some degree of wave crest elevation (8-10%) during shoaling of the wave. Wave height is below 3 metres ~85% of the time, and below 4 metres ~95% of the time. Thus, extreme conditions (wave heights of 4 metres or more) occur less than 5% of time.

2.1.2.5 Wave Regime of the West Coast

Since the South Atlantic Anticyclone became established during Tertiary times as the dominant weather pattern impacting upon the West Coast of Southern Africa, prevailing wind and wave direction ranged between south and west, mainly south-southwest to west-southwest.

Wave currents therefore move sediment primarily in a north-eastward direction, upslope upon the West Coast shoreface, while gravity backwash pulls sediment back downslope in a westward direction. The resultant zigzag motion progresses steadily northward. In the nearshore environment, wave-induced bottom-currents are powerful enough to regularly move entire bodies of coarse sediment, and sand-sized sediment during winter storms. Storm winds from the northwest during winter also sometimes move gravel in a southerly direction. The overall effect of these weather forces is to supply the driving force behind migration of large sediment populations along the coastline, predominantly northward. The interaction of wind, waves, and currents in beach and nearshore environments is the main driving forces influencing sedimentation in the beach and nearshore environment. Wave power, size and availability of sediment, beach slope, and backwash velocity are important factors. Wave height is considered to be the most important factor controlling beach morphology (Figure 1). The surf zone is subject to a variation in wave-energy which determines the spectrum of sedimentation regimes in the various areas. Low wave-energy reflective beaches, such as Walviskop in the summer months, contain medium-scale landward-dipping cross-lamination produced by asymmetrical oscillation ripples.

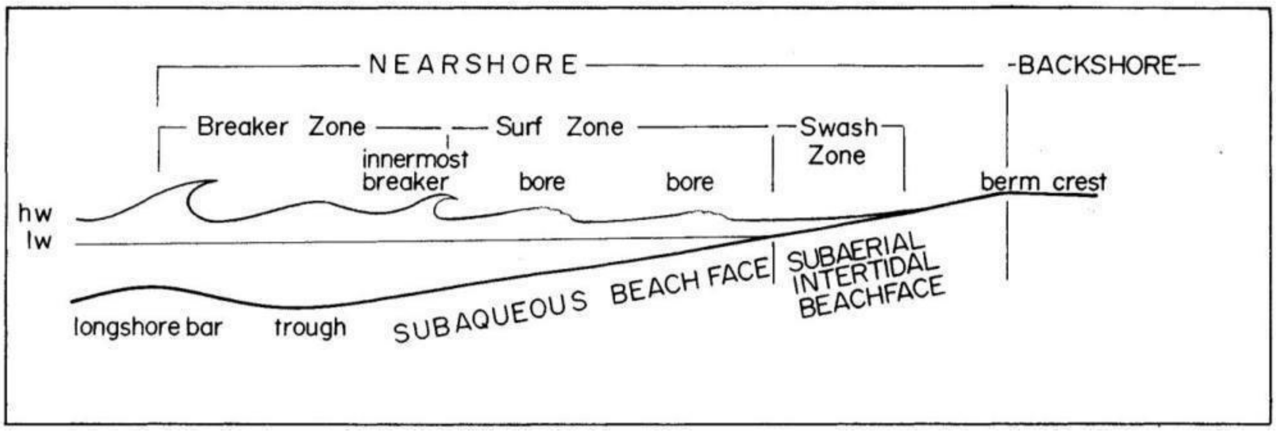


Figure 1: Diagram showing terminology used in this report (after Illgner, 2008). This is a typical beach profile for the Walviskop area which is characterized by a semi-permanent longshore bar and trough (hw = high water line; lw = low water line).

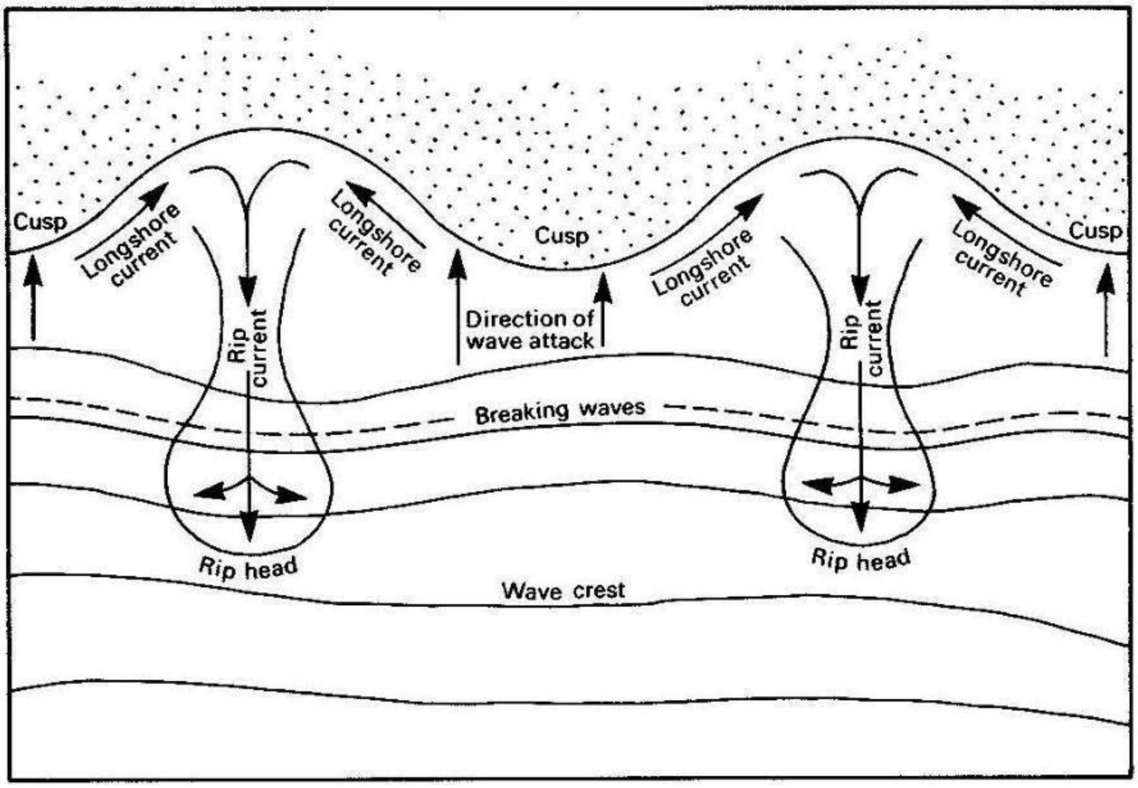


Figure 2: Cusp formation is caused by interactions between longshore and rip currents (after Illgner, 2008).

Cusps are crescentic accumulations of sand between the swash zone and just below the berm crest that vary in height from a few centimetres to as much as 3 m or even more. They are formed of crescentic ridges of coarse sand which surround depressions of finer grained sand. The width of a cusp is seldom more than a few metres. Cusps are ephemeral features, formed by wave action, that migrate along a beach in the direction of longshore drift. They owe their existence to edge waves. These are secondary waves that move at right angles to the primary on-shore waves of the coastal zone. The edge waves cause undulation in wave crests, thereby producing a rhythmic swash line. The uneven swash line, in turn, favours the development of rip currents, which return swash rapidly to the sea and scour-out the "bays" between cusp horns (Figure 2). Cusps occur on many beaches, but are especially prominent where beaches consist of a mixture of sediment sizes (gravel and sand).

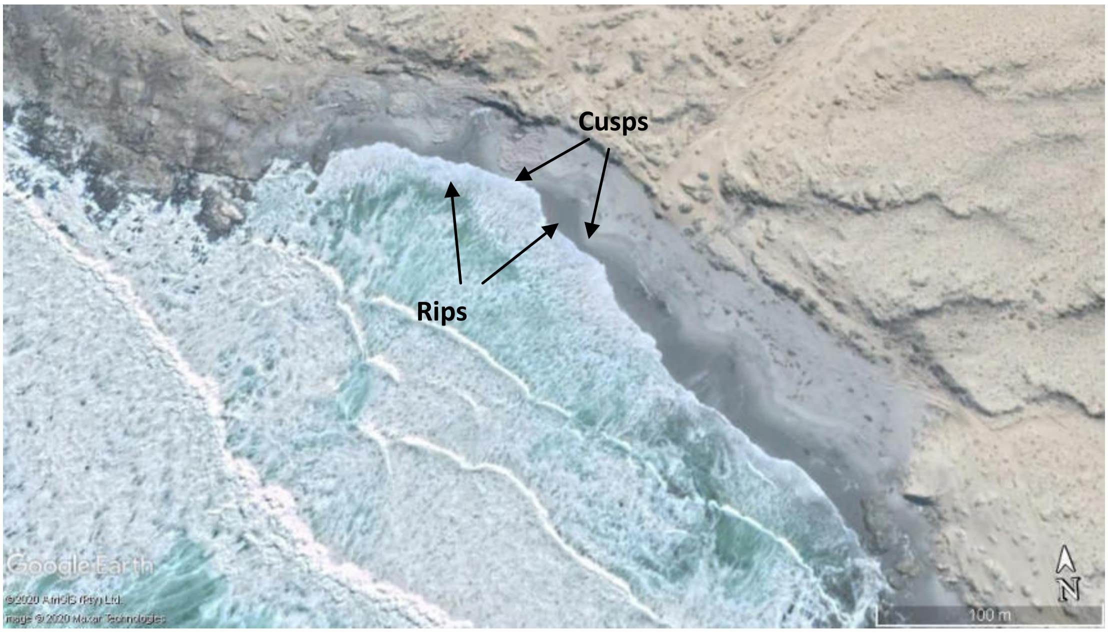


Figure 3: Winter satellite image taken in June 2003 during high tide.

Figure 4: Summer satellite image taken in November 2006 showing clear wave interference.

Figure 5: Winter satellite image taken in June 2010 during low tide.

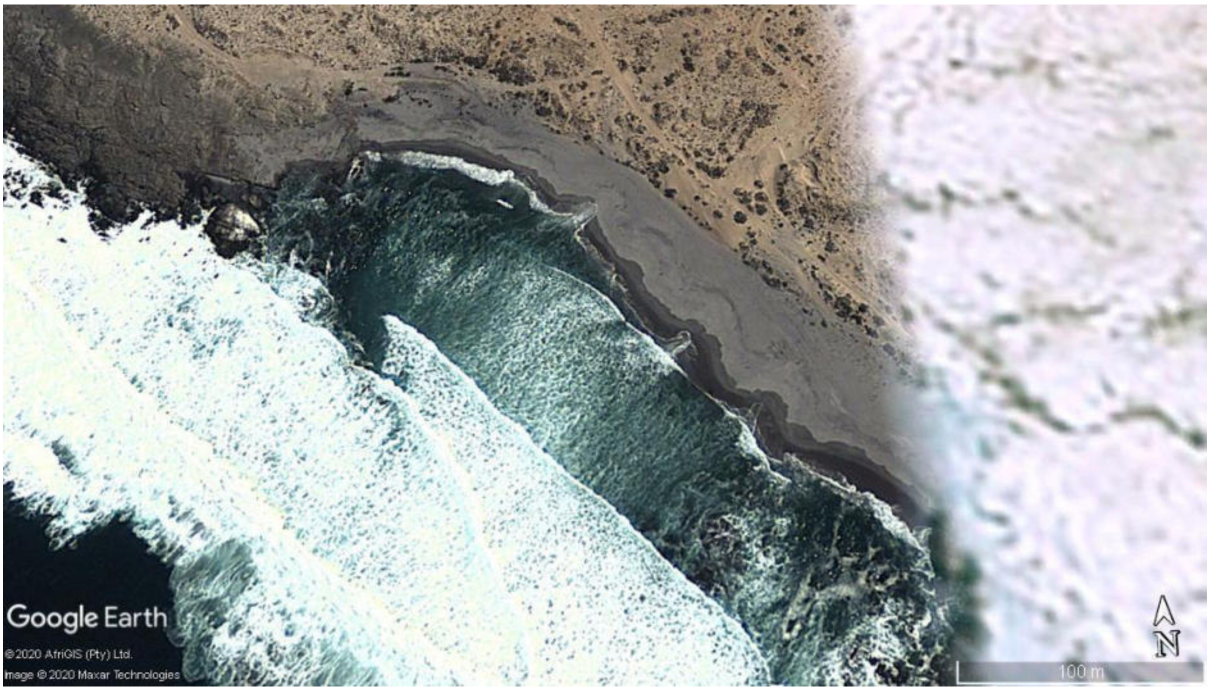


Figure 6: Cusps and rip currents in the nearshore area.

At Walviskop the presence of rip currents that plays a major role in transporting sediment from the swash zone to at least the breaker zone is revealed by the cusp formation on the beaches. This is probably the single most important force in transporting light sediment from the beach back into the bay leaving behind the high density heavy minerals that resists entrainment. This selective entrainment results in the enrichment of heavy minerals on the beach through this process of placer development.

One of the most distinctive features of shallow marine sedimentation, is the frequency of depositional and erosional cycles superimposed upon any given stretch of coast over relatively short periods of geological time. Another distinctive feature is the general tendency of marine sediments to remain unconsolidated for much longer periods than their subaerially exposed counterparts. This facilitates relatively high sediment mobility in an environment of continuous wave energy and enhances the opportunity for placer development providing a good source of heavy minerals is available. In the shallow-marine environment, hydrodynamic boundaries control sediment transport and deposition. Boundaries in turn are controlled by the interaction between homogenous deep wave fronts and coastal bathymetry, resulting in differentiation of wave energy.

These mechanisms are the driving forces behind sediment transport with heavy minerals and quartz sand that are washed into the bay during storm events and then through selective entrainment the quartz is washed back into deeper water further offshore causing enrichment of heavy minerals on the beach of the log spiral bay.

2.2 Beach Mining Operation

2.2.1 Walviskop Sediments

The near shore sediments at Walviskop comprise a marine gravel layer resting on a gently seaward sloping bedrock platform. Here the gravel layer in turn is overlain by a medium to coarse grained beach sand layer. Heavy mineral mineralization occurs predominantly in this beach sand unit and to a lesser extent in the gravel layer.

The bed rock floor on the platform is a very uneven surface with gullies, potholes and large boulders (> 400mm in diameter) in places.

The gravel layer rests on the bedrock floor and varies in thickness between 100 and 500mm. The gravel unit consists of gravel clasts and shell fragments and subordinate sand size material. Clast sizes ranges from > 100mm (8%) to 100 – 2mm (92%) and comprise almost entirely of vein quartz and quartzite.

The overlaying beach sand layer is 3 to 5 m thick on average but after a severe winter storm it can be very thin or even totally absent. The sand comprise a ~50 – 50 mix of coarse to medium grained quartz sand, broken shell material and heavy minerals as a compact well packed sand layer prone to continuous relocation by bottom currents particularly during storm events.

2.2.2 Mineralization

Mineralization of valuable heavy minerals developed predominantly in the sandy beach deposits where very high grade zircon-ilmenite- garnet-rutile-monazite resources formed at well developed south facing log spiral bays such as the bay at Walviskop. The main minerals of economic interest here are rutile and ilmenite (TiO_2), zircon ($ZrSiO_4$), by far the most common zirconium mineral (ZrO_2)

and monazite (Ce,La,Nd,Th)(PO_4,SiO_4), a very good source of a variety of valuable rare earth elements and garnet.

At this part of the coast, heavy mineral suites are diverse and consist of various proportions of ilmenite and its related alteration products, leucoxene,haematite, magnetite as well as rutile, zircon, garnet, amphibole, pyroxene, epidote, aluminosilicates, titanite, monazite, staurolite, collophane and glauconite. The economically viable minerals, ilmenite, rutile, garnet, monazite and zircon constitute a very large portion of the total heavy mineral suite, often an order of magnitude greater than the gangue. Generally, the total heavy mineral suite in the area is dominated by ilmenite (50 – 73 wt%), with garnet (6 –12 wt%), zircon (5 -7 wt%), monazite (2 – 3 wt%), and rutile (1 wt%) constituting the rest of the economic fraction.

The titanium-bearing minerals comprise, in addition to pure ilmenite, a complex suite of Fe-Ti-oxides often intimately intergrown. Single grain analyses indicate that ilmenites contain on average 51% TiO_2 with only trace amounts of impurities. Only a small portion (~8%) of the ilmenite fraction is altered and in most cases alteration was insufficient to enhance the titanium content of the ilmenite fraction. These results are remarkably consistent with previous studies conducted on other west coast localities.

Zircon sand contains zirconium as silicate. Zircon populations were found to be heterogeneous, displaying contrasting physical, geochemical, cathodoluminescent and radiometric properties.

Heavy mineral grains vary in size between 75 and 180µm whereas the gangue minerals such as quartz occur predominantly in the 250 to 500 µm size range.

2.2.3 Process Description

The beach at Walviskop will be mined using an excavator fitted with a dredge pump (hydraulically driven submersible dredge pumps) onto the boom of an excavator feeding directly into a booster pump that will deliver the slurry into a main pipe spine along the beach. The mining rate has been estimated at rate of 260 tonnes per hour based on applying a non-conventional mining method to the project.

The mining operation proposed here will consist essentially of a land-based operation advancing from the beach into the surf zone by carrying a mining tool, the HY 300A hydraulic dredge pump, which will replace the bucket on an 80t excavator (Figure 7, 8, 9 & 10). The pump is equipped with a high-pressure water jet ring system that delivers 100m^3 of water at 6 – 7 bar onto the pump suction area (Figure 10). This water jet system will cause the liquefaction of the sand layer to the extent that the sand in the immediate vicinity of the pump will be kept in suspension through a combination of the turbulence caused by the water jets and motion of the sea water. Dredging will then focus on the suspended sediment comprising mainly sand at a rate of 900 m^3 slurry (up to 50% solids). The mined sediment is pumped from the mining area on the beach, surf zone and breaker zone to the back beach via a 250mm diameter pipe line to the WCP.

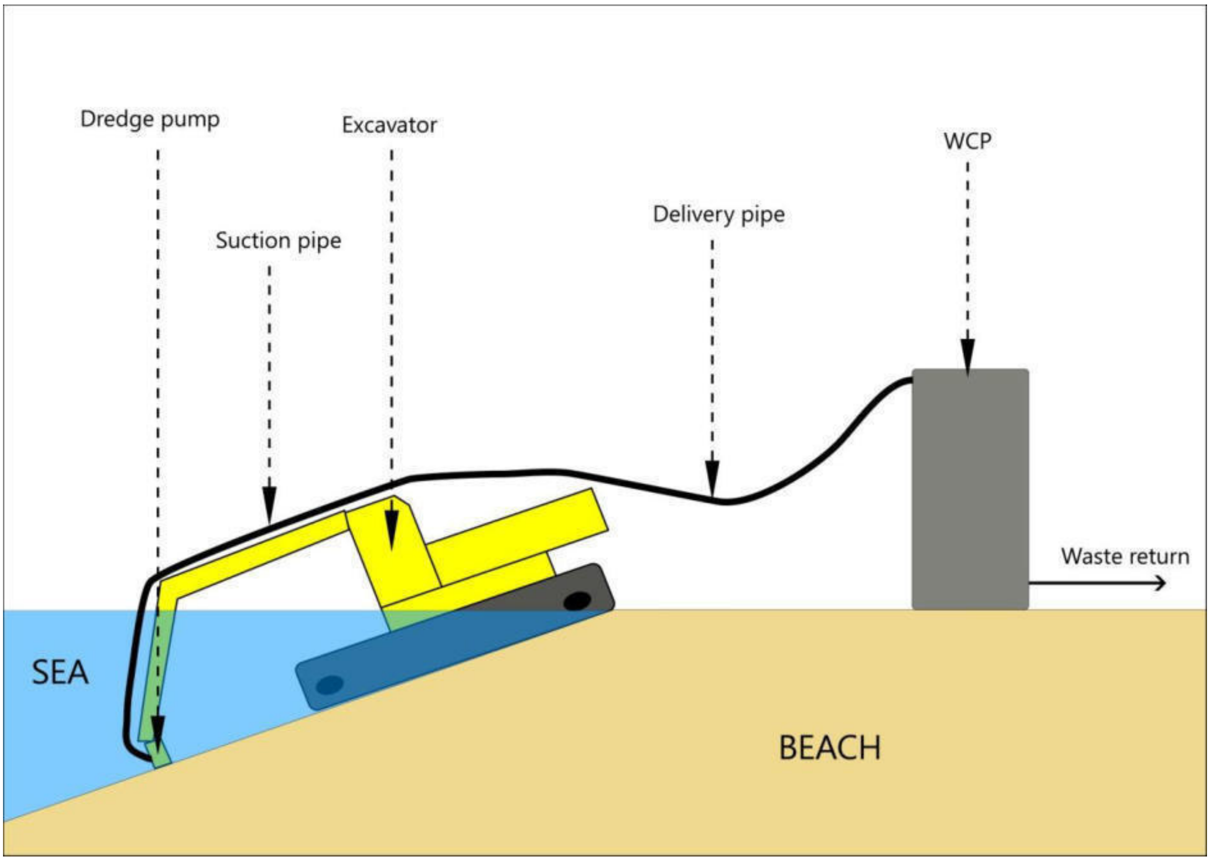


Figure 7: Mining operation on the beach

The sand-size gangue and oversize gravel fraction tailings from the WCP on is considered waste and gets returned to the surf zone by means of gravity flow and gets re distributed and deposited by the wave action on the beach. Mine planning will have to take the direction of longshore drift in to consideration by commencing mining at the down current end of the mining block. The mining will be done by means of a mining tool attached to a high flow rate suction pump. The Dragflow suction tool is attached to the boom of the excavator where it will perform the mining by means of a dredging action. The excavator is equipped with a GPS system to ensure that precise mining take place and that mined-out areas are avoided. Mining will take place at a nominal rate of 260 tonnes per hour at an average utilisation of 75% as a result of beach availability due to tidal events. The mining system is designed at an engineering availability of 85% equating to a mining design capacity of 350tph. The mine area will be divided into mine blocks some 100 x 100m in size and mined from south to north starting with the blocks on the seaward side (Figure 8).

The mining operation will have a main pipe spine that runs along the length of the beach 10m from the cliff bottom. This pipe spine consists of 3 lines: a water line transporting water from the process water dam to the mining operation, a tailings line returning WCP tailings to the beach running adjacent to the water line, and a line transporting ROM slurry to the WCP from the mining operation. There will be tie in points on the pipe spine every 50m along the beach to facilitate the relatively high advance rate along the beach estimated at around 27m per day. The excavators will be connected to the booster pumps using flexible hose that will allow the excavators to move as the mining operation advances.

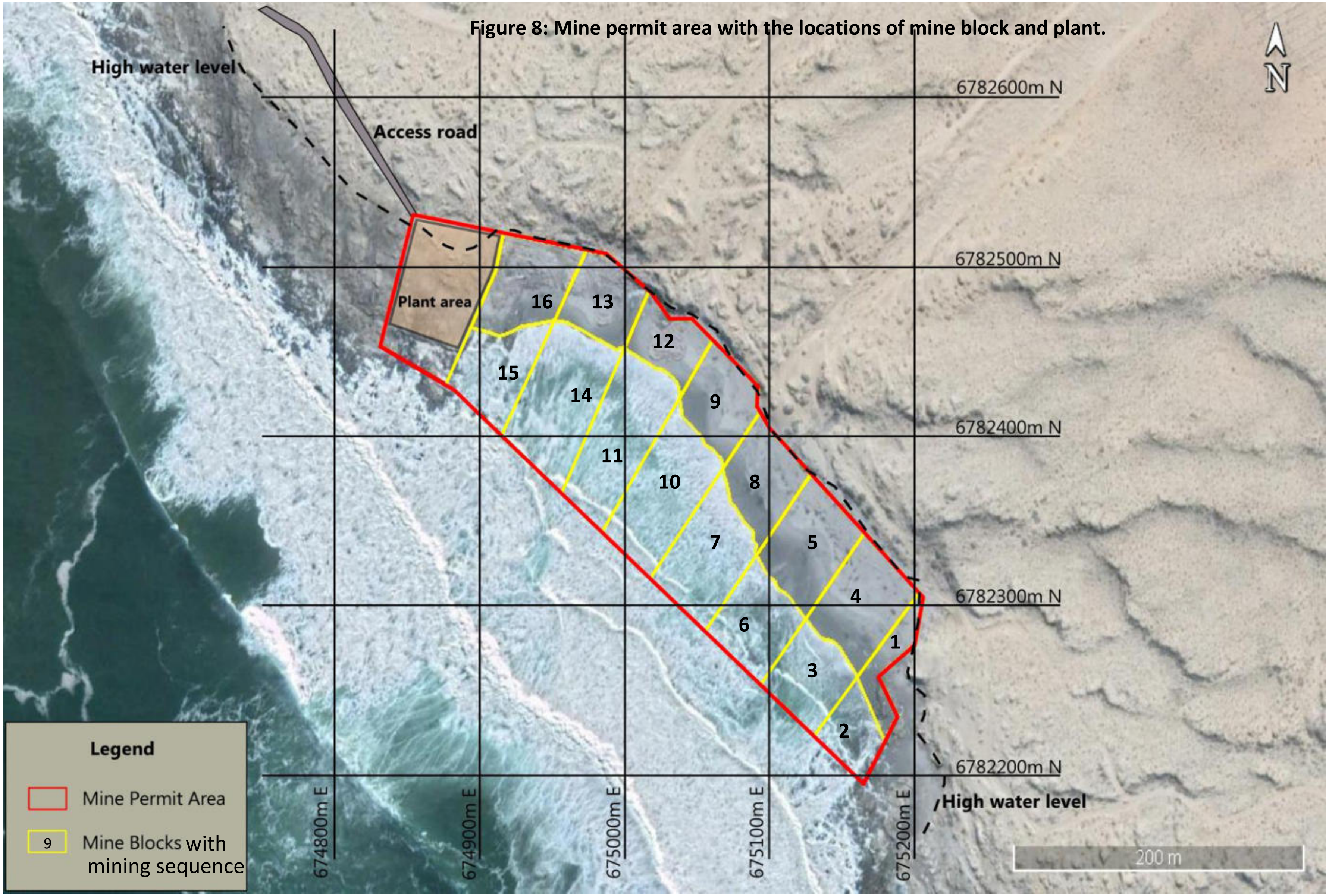


Figure 8: Mine permit area with the locations of mine block and plant.
High water level
Access road
Plant area
6782600m N
6782500m N
6782400m N
6782300m N
6782200m N
674800m E
674900m E
675000m E
675100m E
675200m E
16
13
12
15
14
9
11
10
8
7
5
4
6
1
3
2
High water level
N
200 m
Legend
Mine Permit Area
9
Mine Blocks with mining sequence

The mining operation will receive water from the process water dam as already mentioned, and it is foreseen that the water requirement would reduce as the amount of water in the feed increases with increasing depth of mining. Indications are that only the top 1.5m of sand will be dry and the remainder of the resource 1.5 to 5m deep will be waterlogged.

The process water dam will be fed from a single fixed sea water intake located close to the WCP. The sea water intake (SWI) will be in the form of a well field buried in this section of the beach. The SWI will supply water to the process water dam at a nominal rate of 360m^3/h. The water table at the beach is approximately 1.5m below the surface on average. This would also be a function of the distance from the shoreline and the tide.

2.2.4 Assumptions

The main assumptions used in this costing model were:

a) **Mining plans** were based on a mining sequence where mining started at the southern most end furthest from the plant and progressed northwards towards the plant.

b) **Mining** to only take place 10 metres from the toe of the cliff towards the sea.

c) Mining takes places 16 hours per day for 250 days per year with the assumption that 25% of this time will be lost mainly due to inclement sea conditions.

d) The average **bulk density** of 1.87t/m^3 was derived from the ore reserve estimate.

e) Mining equipment selection is based on Komatsu data.

f) Mining **fuel consumption** figures were estimated from the Komatsu handbook.

g) **Light vehicle** consumption was calculated from the AA Rates manual for Light Commercial Vehicles.

h) **Fuel prices** – as promulgated on 5 February 2020 and obtained from the Shell website.

i) **Pipe distances** were derived from the original haul road calculations and drawings.

j) The mining blocks in the Northern Areas were only mined once while the southern areas were mined at least twice producing some 4.9 million tons.

k) **Roadway maintenance** – will be done using a grader and water bowser with fresh water supply from Muisvlak plant.

l) Logistics – costs included for:

   1. LDV for supervision.

   2. One 25 000L fuel bowser.

m) **Piping and pumping costs** are calculated within the ore processing battery limits.

2.2.5 Mining Machine Selection

Machine capacities and types were selected based on discussions with local operators and OEM suppliers. Komatsu PC800 excavators were selected as the main mining tool as suggested by the suppliers (Figure 9). These machines would be equipped with an extra-long boom capacity which will be sufficient to support the mass of the hydraulic pump over the 18m mining radius. The hydraulic pump will replace the excavator bucket being fitted to the excavator arm and connected to the hydraulic system of the excavator (Figure 10). To support the PC800 excavators in moving the 250 mm (10 inch) pipes on the beach, one PC 300 excavator has been selected. The movement of piping on the beach is a cumbersome task and will require relatively heavy equipment to achieve. These machines will also play an important role in removing equipment from the beach should sea conditions so require. Komatsu have a strong presence in the area and are prepared to enter into repair and maintenance contracts. Therefore, for the purpose of this exercise, the Komatsu pricing and maintenance schedules were used.

Figure 9: An 80t excavator equipped with a long reach 4,6m arm and an 8,2 m boom and 1 010 mm double grouser shoes. The bucked gets replaced by a hydraulic pump fitted by means of a quick release attachment.

Figure 10

DRAGFLOW HYDRAULIC PUMP HY300A

- Solid concentration can vary from 5% to 70% by weight of pump capacity due to the kind of material to be pumped, the delivery distance, the working depth, static head and dredging operation
- They are suitable to handle high abrasive materials thanks to low rotation speed which decreases wear and tear to the parts subjected to abrasion.
- Solids passage: 120 mm

Technical specifications

- Weight: 3.500 kg (A model)
- Cross Section: 120 mm
- Impeller: 2 vanes closed / Diameter: 760 mm
- Delivery diameter: 250 mm (A model)

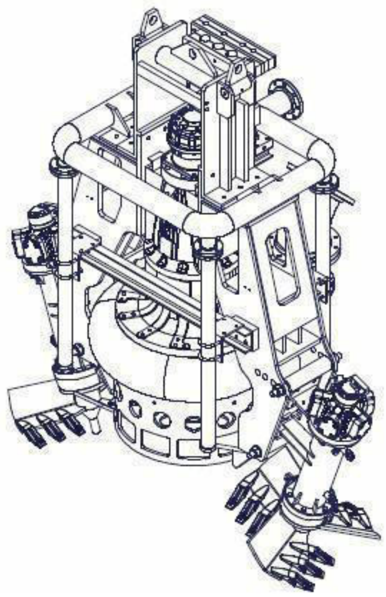
Motor

- Speed min-max: 600 - 750 R.P.M.
- Power min-max: 110 - 214 kW (150 - 292 HP)
- Need of oil min-max: 300 - 375 l/min
- Oil pressure min-max: 230 - 350 bar
- Motor displacement: 500 c.c.

Materials

- Main body: Spheroidal Cast Iron GS500
- Motor housing: Cast Iron G25
- Wearing parts: High Chrome
- Main Shaft: Austempering NiCrMo4 Steel

High pressure water ring jet system with 4 x 25mm nozzles and a 150mm inlet.



DRAGFLOW HYDRAULIC PUMP HY300A fitted with

A high pressure water ring jet system and two

excavators (optional)

This pump is attached to the excavator by means of a quick coupling system.

Although construction and maintenance of the roadways has been reduced significantly from the baseline mining study, maintenance of these roads from a health and safety perspective is still a necessity and provision should be made for this in the processing estimate. The fuel bowser capacity has been increased from 20 000 - 25 000 litres to ensure sufficient availability of fuel for the additional booster pump stations.

2.3 Mechanical and Piping

2.3.1 Description

The design has been based on the following parameters:

Dry Solids Feed Rate = 260tph + 20% Design Factor.

Slurry Flow Rate = 907m^3/h + 20% Design Factor.

Solids SG = 3.63t/ m^3

Slurry SG = 1.27t/ m^3

Pipe Length = 5,000m

Static Head = 46m

Cyclone Structure Height = 15m

Cyclone Feed Pressure = 7.5m

Total Static Head = 68.5m

Durand's Limiting Settling Velocity calculation was used and the Warman table on "solids for widely graded sizing" was used to determine Friction Loss. Due to Durand's formula being very conservative we used 80% of the calculated Settling Velocity to determine the minimum pipe sizes.

To calculate the Required Power the following calculation was used:

Required Power = (Absorbed Power X Drive Loss Factor X Friction Losses in Fitting or Transmission Factor) / Pump Efficiency

Drive Loss Factor or Safety Factor = 20%

Friction Losses in Fitting or Transmission Factor = 5%

The piping selected for the project was PE 100 HDPE PN 10 complete with galvanised flanges

drilled to SANS 1123 T1000/3 FF.

2.3.2 Scope

The beach mining operation consists of 2 ROM Transfer Pumps spaced along the pipe route. The first pump will be fed by the hydraulic dredge pump mounted on the excavator. Followed by a series of booster pumps feeding the ROM stacker cyclones.

ROM Feed

- 2 x Warman 10/8 AH Metal Pump c/w 275 kW Diesel Engine, all skid mounted.
- 1 x 250 NB x 1,000 mm long Rubber Hose to connect overland piping to the suction side of the pump.
- 1 x 200 NB x 1,000 mm long Rubber Hose to connect the overland piping to the discharge side of the pump.
- 250 x 12,000 mm lengths of 355 OD HDPE PN 10 pipe flanged both ends to SANS 1123 T1000/3 FF galvanised.
- 100 x 12,000 mm lengths of 355 OD HDPE PN 10 pipe flanged both ends to SANS 1123 T1000/3 FF galvanised, c/w 355 Dump T.
- 100 x Dump T's.
- Note that the flexible hose delivering ROM slurry to the first booster pump from the Hydraulic Dredge pumps has been included with the Hydraulic Dredge pump cost.

Sea Water Intake

The sea water intake (SWI) consists of an underground of perforated pipes routing water to a central well pipe. Water is pumped from the central well pipe to the WCP process water dam as required.

- 1 x Warman 6/4 AH Metal Pump c/w 110 kW Diesel Engine, skid mounted.
- 135 x 12,000 mm lengths of 250 OD HDPE PN 10 pipe flanged both ends to SANS 1123 T1000/3 FF galvanised.
- 14 m 450mm OD HDPE PN 10 piping cut to suit
- 1 x 8m length of 450 HDPE PN 10 pipe flanged both ends to SANS 1123 T1000/3 FF galvanised
- 1 x dump tees

2.4 Civil

The only civil work included in the beach mining section relates to the access roads to the platform above the beach, where provision has been made for a plastic lined culvert to hold the main pipe spine as well as run off diversion from the main road (Figure 11).

The culvert for the main pipe spine runs parallel to the access road and has an earth berm on either side to keep any spillage as a result of a bust pipe away from the dune vegetation and channel it down to the beach. Run off during rainstorms will also be drained from the road to the culvert where it would run down to the beach without eroding the access way.

The access way itself will be designed in such a way that water will not erode the surface and cause instability in the cliff adjacent to the access way.

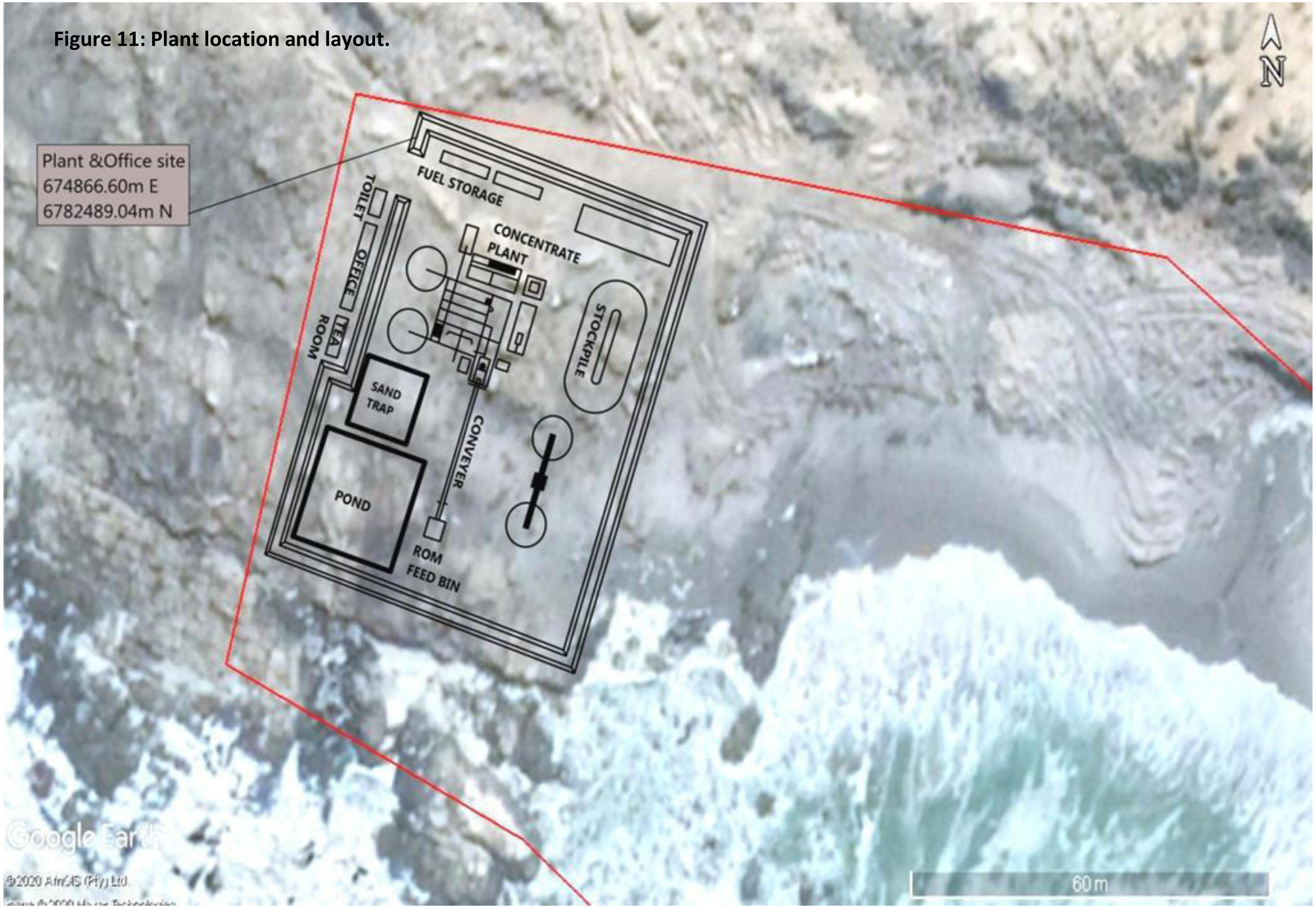


Figure 11: Plant location and layout.

2.5 Electrical

The electrical scope on the beach will be limited to area lighting that will be mounted on the pieces of equipment on the beach i.e. the booster pumps. The electrical supply for the lighting will be run from an alternator on the equipment diesel engine.

2.5 Process Control and Automation

There are three main functional areas in the mining section: Water supply to the beach, ROM feed to the main pump spine and the main pipe spine that transports water and slurry along the length of the beach.

The ROM supply to the pipe spine is delivered by two excavators fitted with Hydraulic Dredge pumps. The excavators have on-board flow and density control, and work to a set point of 30% solids by mass to the main pipe spine by controlling the water addition, pump speed and pump position.

The main pipe spine receives the ROM in slurry form from hydraulic dredge pump at the first booster pump station. Water addition will also be supplied at this pump station of ; this water will maintain the flow in the pipeline at low flow conditions from the dredge pump.

The sea water intake (SWI) maintains the level in the process water dam. Water is supplied to beach mining operation through the mining water supply pump from the process water dam. Water addition to the ROM stream is controlled by a motorized valve and adds water when the flow meter on the discharge of pump measures a low flow condition.

The excavators will receive an alarm when the pressure in the discharge header exceeds normal operating parameters indicating that there is an obstruction in the main pipe spine and that the line should be flushed. The booster pumps on the main pump spine are interlocked with each other. All instrumentation in the beach mining section communicates with the main plant PLC via a radio link.

Each of 2 stations will be fitted typically with a 25IO MicroLogix 1000 PLC operated off 24VDC from the battery system of the Diesel engine. The latter will be mounted in a remote station radio panel. These systems will be able to monitor 6 digital inputs, 2 analogue inputs, 8 digital relay outputs and 1 analogue output. As a result of this the operator will have the ability to operate the diesel pumps from the control room and receive indication of the status of the units.

The radio signals are fed to a 105U gateway on the plant which supplies the data onto the Ethernet network connected to the PLC.

Communications to the plant personnel will be done by two-way radios that have been included in the estimate.

2.6 Wet Concentrator Plant

The wet concentrator plant (WCP) will be located well above the beach where it will receive sediment at a rate of approximately 260t per hour (Figure 11). The WCP receives ROM slurry from the beach mining operation and produces tailings that is sent back to the beach mining operation and concentrate which is bagged and dispatched from the concentrator plant. Provision has also been made for a five-day ROM stockpile and a Low Grade concentrate stockpile. The plant will use water from the process water dam.

2.7.1 Process Description

WCP Feed Reception

The rate of production at the mine excavation is estimated to be 260t/h solids and the WCP has a capacity of between 208 and 210t/h (+/- 20%) solids. The 260t/h mining rate is considered an average rate and depending on the water content in the beach sand, the ratio water to sediment could vary and supply from the water supply pump will decease while working high up on the beach as opposed to down below water level. This will result in the slurry density increasing and decreasing depending on the working area resulting in the 260t/h figure being a minimum number that could increase as much as 5-6%.

At the WCP the slurry flow into the plant will be carefully controlled not to overfeed the plant with the excess feed being diverted to a dewatering/stacker cyclone system that will stock pile the dewatered sand on a stock pile pad for use in the plant should the mining unit not being able to supply slurry directly to the plant due to unavailability during routine maintenance, refuelling, unexpected breakdowns of the excavator-pump unit or high sea stand on the beach area. Enough material will be collected on the stockpile pad to cover 5 days allowing for a serious mechanical failure at the excavator/pump or rough seas during severe storm conditions.

Slurry from the mining operation will report to the ROM stockpile(s) via the stacker cyclones which will dewater the material. The ROM stockpiles will be reclaimed by means of a front-end loader and placed on an adjacent stockpile. The ROM stockpiles will have a collective capacity of 5 days plant capacity.

Water run-off from the ROM stockpiles will be channelled to the process water dam. ROM ore will be fed into the WCP directly from the dredge via the pipe line that will discharge the material into a trommel screen acting as a tramp removal screen with a cut point of 2mm. The oversize will be stockpiled while the undersize is discharged into a densifying cyclone and from the cyclone to the primary sluices (spiral banks) (figure 12).

The ROM feed will be controlled by the density meter on the rougher feed discharge in order to feed the pulp into the rougher circuit at a constant density. The level of the rougher feed bin will be maintained by an actuated valve linked to a level sensor in the rougher feed bin.

Water will be stored at the plant site in a lined earth dam (process water dam, PWD). The water supply will consist of the cyclone overflows from the stacker cyclone on the ROM stockpile as well as make up water from sea water intake (SWI) and return water from the plant. The water level in the process water dam will be maintained by the SWI that will be linked to a level instrument on the PWD.

The PWD will include a self-cleaning sand trap that will overflow into the main PWD with streams carrying solids reporting to the said sand trap. Silt will be removed from the PWD by a submersible pump that will be permanently mounted in the sand trap, the silt will be pumped into the PWD overflow where it will be allowed to return to the beach.

There will be an overflow which will return water to the beach when the mining operation is producing water in excess of the losses to tailings.

Gravity Concentration Area

Material from the densifying cyclone will be fed to the primary sluices (rougher spirals) via a 4-way pressure distributor.

Four banks of 12 triple start rougher spirals are required. The rougher concentrate will report to the LIMS feed bin in the magnetic concentration area of the plant. The rougher middlings will report to the Midds Scavenger Feed Bin and the rougher tails will proceed directly to the Final Tails Bin.

The Midds Scavenger Spirals receive its feed from the Midds Scavenger Feed Bin. The Midds Scavenger Spirals consists of two banks of 10 triple start spirals. The concentrate from the Midds Scavenger Spirals reports to the Cleaner Feed Bin and the tails to the Final Tailings Bin. Make up water for the Midds scavenger bin is received from the tailing's densifier cyclone.

The Midds Scavenger concentrate, and the scavenger concentrate are fed to the cleaner spirals. The cleaner feed is pumped from the Cleaner Feed Bin to a single bank of 8 triple start spirals. The concentrate from this stage joins the rougher concentrate in the LIMS feed bin with the tailings being further treated in the scavenger spirals.

The Scavenger Spirals consist of a single bank of 4 triple start spirals. The concentrate reports to the Cleaner Feed Bin and the tailings proceed to the Final Tails Bin.

In general, there is a water shortage in spiral concentrate bins that requires water to be added to reach the desired density for pumping. Water is thus transferred between bins to limit the total amount of water that needs to be pumped into the plant.

A common sump is located below the process equipment for the containment of spillage; hosing points have also been provided in the area.

There will be no product collection launders feeding into the sumps and all spiral products will be piped directly to the said sumps.

Concentrate Handling Section

The concentrate handling section is fed directly from the Concentrate Bin. The high-grade concentrate is dewatered by either one of two stacker cyclones, one located at the bagging plant and another at the emergency stockpile.

The low-grade concentrate reports to a dedicated LG concentrate stacker cyclone that discharges on the LG stockpile.

The combined cyclone overflows are re-circulated to the rougher feed bin.

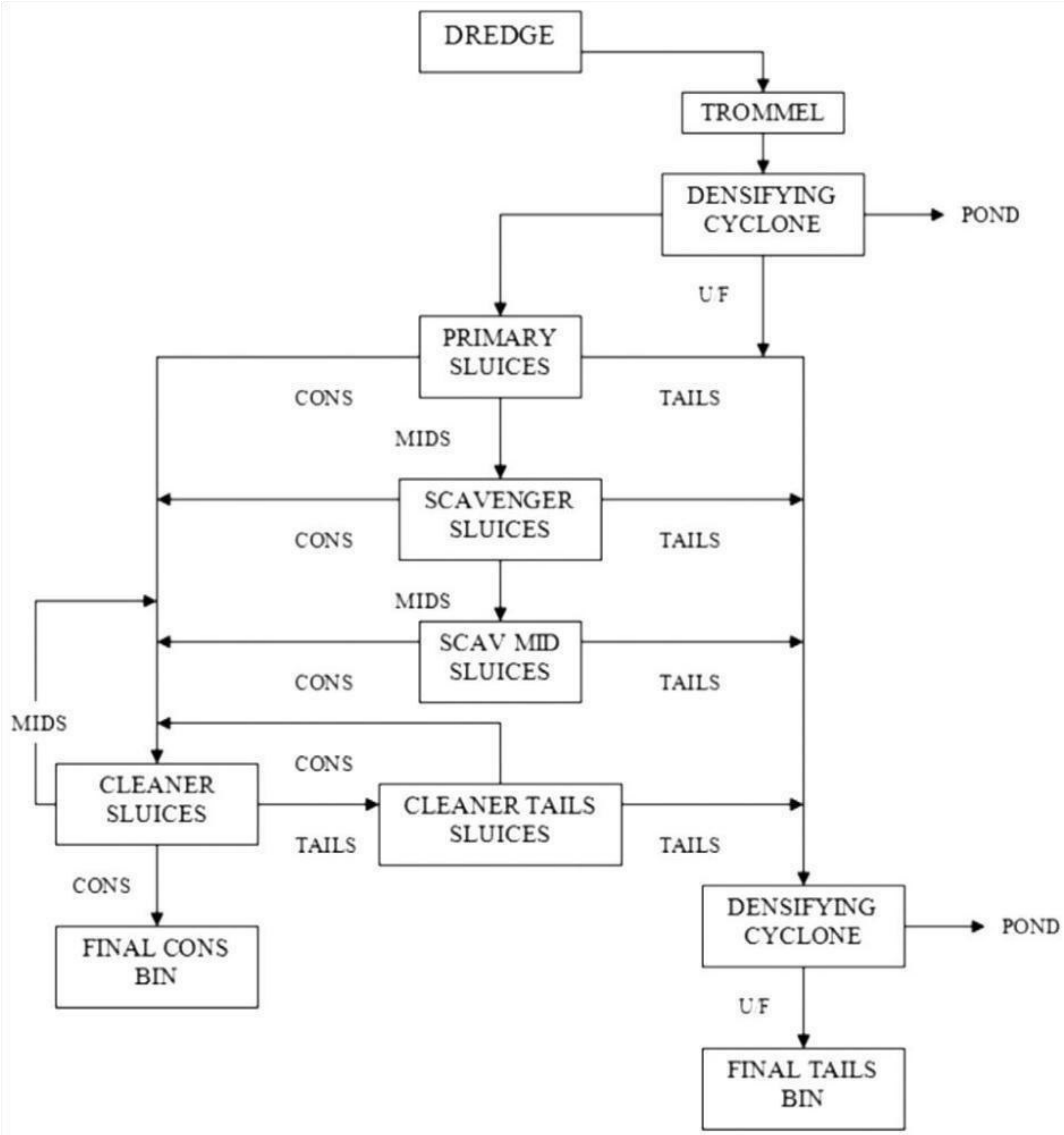


Figure 12: *WCP Feed Reception and Gravity Concentration Area*

2.7.2 Mechanical and Piping

The Wet Concentrator Plant was designed on the following parameters:

Material Handling

Dry Solids Feed Rate = 210tph +20% Design Factor

Slurry Handling

Dry Solids Feed Rate = 208tph +20% Design Factor

Solids SG Range = 2.70 to 4.44t/ m^3

Slurry SG Range = 1.03 to 1.34t/ m^3

Durand's Limiting Settling Velocity calculation was used and the Warman table on "solids for widely graded sizing" was used to determine Friction Loss. Due to Durand's formula being very conservative we used 80% of the calculated Settling Velocity to determine the minimum pipe sizes.

To calculate the Require Power the following calculation was used:

Required Power = (Absorbed Power X Drive Loss Factor X Friction Losses in Fitting or Transmission Factor) / Pump Efficiency

Drive Loss Factor or Safety Factor = 20%

Friction Losses in Fitting or Transmission Factor = 5%

The piping selected for the plant is PE 100 HDPE PN 10 complete with galvanised flanges drilled to SANS 1123 T1000/3 FF.

Galvanised mild steel is selected for small bore piping (50 NB) required for the screen spray and hosing down points.

The High-Pressure Water circuit was designed for 6 bar discharge pressure at the pump for flushing of lines, supply to hose down points and Fire Water supply providing to strategic points around the WCP modules, e.g. each spiral bank.

The WCP Water Supply circuit was designed for 4 bar discharge pressure at the pump for screen sprays as well as make up water for the plant.

Warman AH rubber lined pumps are selected for the plant and these range from a 10/8 down to a 4/3 model. The pumps feeding the spiral banks are fitted with Variable Speed Drives (VSD) which give the plant some flexibility if one of the spiral banks is down due to blockage or maintenance, then two or three spiral banks can still be operated.

All tanks are designed on a rise rate of 0.5 m/minute. The tanks are fabricated from mild steel, rubber lined, and corrosion protected for the harsh marine environment. A freshwater wash has been included using a hydro-sizer that is provided with desalinated sea water from a reverse osmosis plant.

2.7.3 Tailings discharge

Some 40 - 50% of the mined sediment will be retained as concentrate and the remaining 50 to 60% will be discarded as tailings. The tailings will be discharged into a steel bin (sump) from where it will be pumped back to the mined-out areas in the surf zone. Here the tailings will be discharged back to the mined-out areas in the surf zone via a 250mm diameter flexi hose.

Should prevailing conditions allow, the tailings will be piped back (gravity flow) to the surf zone just south of the plant from where the released sediment will move southward and will be washed back onto the beach south of the plant. This would take place by the southwards flowing counter current eddy driven by the northward moving longshore drift that will take the sediment dispersed at the outlet in the surf zone and will get re-deposited onto the beach and thereby re-establishing the beach in the same manner as normal sediment accumulation on the beach takes place.

Should this sediment dispersal not follow the processes anticipated above then it will have to be pumped to the surf zone at the excavation for redeposition.

Gravel particles will settle upon discharge in the excavated depressions at the mined out areas where as the sand will stay in suspension for some time before settling. Tailings discharge will take place by constantly moving the discharge pipe outlet along with the excavator by placing the outlet on the mined outside of the excavator in order to make use of the longshore drift and rip currents to back fill the mined out areas and not to dump tailings in the areas that still needs to be mined. Tailings should under no circumstances be discharged onto rocky outcrop areas.

2.8 Civil and Earthworks

2.8.1 Earthworks

The entire plant area will have a plastic lining to be in line with the environmental management plan. The intention of the plastic lining is to contain all possible sea water drainage. The plant will also have a berm around it to contain spillage run off.

I. The whole of the WCP area will be excavated to a depth of 500mm and the ground will then be scarified and compacted to 90% modified AASHTO density.

II. All excavated sand will be stockpiled for re-filling of area.

III. The areas for the sand trap dam and the process water dam will be excavated to the correct dimensions.

IV. Suitable plastic sheeting will be laid over the whole area including that of the dams. The stockpiled sand will be backfilled to NGL, compacted to 90% modified AASHTO density in 150mm layers. Ground slopes are directed towards the sand trap dam.

V. Berms will be constructed around the periphery of the site and around the dams using imported material.

VI. A weir arrangement will be incorporated from the sand trap dam to the process water dam.

VII. A diamond mesh fence will be erected around the site periphery making an allowance for a 4m wide gate at the entrance.

VIII. A diamond mesh fence will be erected around the dams with a 4m wide gate at the entrance and a pedestrian gate on the opposite side for emergency exit.

IX. Trenching and preparation for the overflow pipe from the process water dam to the beach will be completed.

2.8.2 Roadworks

I. The area between the existing road and the WCP area will be excavated and layer works constructed for an access roadway for a distance of some 200m north of the WCP.

2.8.3 Civils

Concrete bases will be constructed for the WCP, the ROM gantry, plant buildings and product storage areas.

I. A base will be constructed for the ROM Stockpile Gantry.

II. Bases and surface beds provided for the workshop and storage buildings.

III. The following appropriate surface beds will be constructed:

- Fuel storage area – allowance for oils and spillage bund.
- Bag storage area.
- Laboratory.
- Ablution block c/w sewage and waste disposal facilities.
- Office block.
- Tea room.

IV. A trench will be prepared, and concrete lined for a spoon drain from the WCP to the sand trap dam.

V. All stockpile areas will be compacted to 93% modified ASHTO. The G5 imported material levels will be to falls draining towards the sand trap dam. Appropriate surface beds will be provided for the generator, MCC and Control Room.

VI. A bunded area will be provided for the 'day fuel tank' for the generator

VII. Bases for the ROM Feed Conveyor will be constructed.

VIII. The concrete beam arrangement, surface bed and sump area under the WCP will be constructed.

2.9 Structural

Structural design works comprise the following:

I. ROM Stockpile Gantry incorporating 2 cyclone discharges.

II. WCP modular construction inclusive of stair modules and screen and rougher bin modules.

III. Cyclones mounted on jib arms for the high grade, low grade and bagging shed.

IV. ROM feed bin and feed conveyor.

V. Bagging plant.

VI. MCC support platform.

VII. Workshop.

VIII. Storage shed.

The WCP modules have been designed to be abnormal loads that will not clash with power lines while being transported to site.

2.10 Electrical and Instrumentation

2.10.1 Plant Operation

The plant will be operated via a SCADA system in the control room. The control room will be container based and mounted on top of the MCC container. The SCADA system will be RSView and was chosen as it interfaces well with the Allen Bradley PLC.

2.10.2 Management System

The project includes a management system that can be used by the plant manager as well as a 3 Com link that will allow for internet access and dumping data for access by a third party to data stored on the server. The office will communicate to the plant PLC via radio telemetry to facilitate moving the plant at a later stage.

2.10.3 Energy Supply

Power to the plant will be supplied via two generators, one rated at 1.8MW and the other at 160kW. The 160kW generator will only be used for construction power and on maintenance days when the main unit will be switched off. The standby generator is sized to run the 110kW fire pump (soft starter is incorporated on the pump) as well as the plant lighting and the welding plugs. The unit price included in the E&I tender is for a second-hand unit that has 2000h on the engine. This is deemed to be in order as the unit will only be needed on a standby basis.

The main generator will be sized according to the load, sized at 40% above the running current of the plant. The biggest motor to be started is a 160kW, however a soft starter should be included for all motors 100kW and above. The diversity factor on the motors was chosen at 10%. A design factor of 1.2 is included when specifying the motor powers. The chosen load of the motors is thus 72% of name plate current. As this is a plant with most of the pumps in line, a diversity of 10% is not deemed too high. There were no standby pumps allowed for or taken into account. The loading factor for the 6 welding plugs was chosen as 20%. If all the pumps are running, then the load on the generator increases to 1 431kVA and thus still within the maximum rating of the unit.

2.10.4 Voltage Drop

If the plant is running and the 160kW motor is started with the soft starter set at 300% of nominal current, then the voltage on the bus will drop to 92% which is well above the 85% minimum allowable. Low voltage cables will be to SANS 1507 600/1000V grade having steel wire armouring. Power cables in general will be 4 cores.

2.10.5 Energy Meter

An energy meter will be connected to the incoming section of the MCC and will be used to monitor the consumption of electricity as well as doing a routine check on fuel consumption of the generator. The meter will be connected via Ethernet for reporting purposes onto the server.

2.10.6 Earth Mat

Earthing will be done based on the final design by the appointed engineer and will result in a lightning protection resistance of less than 10Ω and a grounding resistance of less than 1Ω. The system will be designed and installed as specified and in accordance with the SANS Codes of Practice 10199 (2004) and 10313 (2008) in conjunction with SANS 62305-1-2-3-4:2007 and IEC 62305 -1-2-3-4:2006. The earthing system design is such as to provide a uni-potential system with all equipment being effectively earthed at a single earth potential. The interconnection of earth systems will be radial in nature to prevent the possibility of circulating currents, particularly in the vicinity of cable racks and pipelines.

2.10.7 Fault Current

The fault current is made up of two components, the generator and the effect of the motors to a direct short.

The panel ratings are 50kA and all 525VAC equipment will have fault ratings above 35kA. It is not possible to do fault current predictions for the future when an ESKOM supply is obtained, however the ratings are high enough that this should not pose a problem.

2.10.8 Welding Power

Allowance has been made for 3 feeds with two welding plugs per feed of 63A each. The welding plugs are supplied with 550VAC and this will have to be taken into account by the site contractors. Each welding plug is to be fitted with an earth leakage unit.

2.10.9 Construction Power

No allowance has been made for construction power as the units are modular, being built at the supplier's premises, then transported to site and stacked in place. The standby generator will be available for the time the plant is being built as the unit is immediately available. The lead times on the MCC and all related equipment is 10 – 12 weeks and thus this can be ready long before the modules will be on site. The electrical container can also be made available to the module supplier for factory testing of his equipment.

2.10.10 Small Power

Small power was designed according to SABS0142:1993. The following areas will be supplied by small power:

Control room distribution board – 10kVA

UPS supply – 5kVA

Office supply – 50kVA

Plant lighting – 50kVA allowed, actual 22kVA

Maintenance workshop – 100kVA

The small power panel will be supplied by a 150kVA transformer.

2.10.11 Diesel Power

The 68,000l diesel tank will be supplied with 550VAC and this needs to be taken into account when the vendor for the supply of the tank is informed of his contract. The E&I contractor will supply the cable to the vendor distribution panel. As the lighting levels are low in the area, about 10 lux, (the assumption is made that all loading and pumping of diesel will occur in the day) if additional lighting is required then this is to be obtained from the 550VAC feed to the tank.

2.10.12 Plant Lighting

The plant lighting will be supplied via a three-phase supply to a DB where the individual single-phase lights will draw power. The DB will be fitted with a day/night switch.

There will be 5 different lighting DB box configurations as shown by the alpha numeric characters in red in the diagram below. The panels will be IP65 noncorrosive enclosures with exterior mounting facilities and tamper proof locking facility, similar to ABB GRP type enclosures. The plant lighting load will draw 82.27A single phase in total or 18kW. It is assumed that the control room and the offices will be supplied with lighting as they are container or modular based systems. Allowance will therefore not be made here for them.

Emergency lighting will be performed by standalone BEKA VLN 4x55w/EMG luminaries enclosed in an IP65 fitting with electronic control gear. The emergency control gear will operate the lamp for 1h at 50% light output. There will be an emergency light per module.

No high mast lighting has been allowed for. The conveyor lighting will be achieved form the 100W HPS lighting mounted on top of the modules.

2.10.13 Conveyor

Pull keys, single and double pole, will be installed every 80m on both sides of the conveyor belt for safety purposes (thus one set of pull keys for the conveyor). In case of the activation of a pull key (by human or other means), the design of the MCC (motor control centre) is such that the conveyor belt will be tripped. This is essential to comply with safety regulations and procedures.

The following Conveyor belt equipment will be covered under the Instrumentation Scope of Supply:

- Start-up sirens
- Belt alignment units
- Speed switches
- Electromechanical belt scales

2.10.14 Process Control System

The plant will be fully automated as far as is practically possible. All equipment will be stopped and started from the control room. Field start facilities are not provided. Sequential plant start-up and shutdown will be automated. Where operator input is required during the start-up sequence hold points will be provided. As equipment will be started remotely warning sirens shall be provided before any major equipment is started. Interlocking of all equipment will be via the PLC. Field stops and safety circuits directly affecting human safety are hardwired in line in the form of local isolators. The variable speed drive local isolator stations will have “early make late break” facility.

Extensive diagnostics will be incorporated into the system to allow fault finding quick analysis. Feedback to the PLC will be performed using Device Net communication. The PLC will communicate to the telemetry base station, bagging plant, RO filter and SCADA using an Ethernet platform. The SCADA System will gather the information from the PLC and analyse and distribute the information to the operator view nodes in the control room. The nodes in the control room will be capable of full control and access to all the information including all alarms and historical data. Certain functions will be password protected (i.e. loop tuning parameters) and will only be modified by authorised personnel.

The Functions of the SCADA system is to provide:

- An operator interface to the plant to monitor status of equipment.
- An interface to the plant to control and set-up equipment.
- Historical information to diagnose the circumstances leading to a malfunction.
- Historical information for process optimisation.
- Alarms and warnings to the operator.
- Data logging and event recording.

- Process data and print reports

The PLC will be powered through a 5kVA UPS. The UPS will also feed the plant SCADA computer.

3. SUPPORTING INFRASTRUCTURE

3.1. Offices

The offices that will be provided will consist of a single prefabricated unit that will house two offices and a meeting room.

Tee/Change Room and ablutions

3.2. Tea/Change Room and ablutions

Provision for rest and ablution facilities for the labourers have been made by means of a tea room, change room and ablution facilities. These facilities will be provided with potable water trucked in from Muisvlak (some 16km by road) once a week.

3.3. Laboratory and Sample Treatment

The laboratory is limited to sample preparation with sample analyses being done off site. Basic equipment for the drying splitting and weighing of samples will be provided. The laboratory and concentrate dispatch will be linked.

3.4. Workshop and Stores

The workshop will cater for repair of plant equipment with the exclusion of mobile and equipment with diesel engines that will be serviced at the dealership and contracted out respectively. The only mining equipment that will be serviced in the workshop will be the hydraulic dredge pumps. There will be an electrical, control and mechanical section in the workshop with basic maintenance equipment for repair of major pieces of equipment. The workshop will be set only to replace major components. The stores in the plant will cater for all consumables as well as major spares; all deliveries to the operation will be done through the stores. The workshop and stores will be located at the plant site.

3.5. Roads

Allowance has been made for the preparation of 900m of an existing dirt road leading to the plant by replacing the sub layer with 900mm of calcrete material and resurfacing with compacted calcrete material.

3.6. Concentrate Transport

Provision has been allowed for the storage of 3 days of bagged or bulk concentrate production on concrete slabs. The concentrate bags will be stacked up to three high by means of an all-terrain forklift that has been included. Concentrate will be moved from the wet concentrator plant site by an outside contractor.

APPENDIX H:

CONSTRAINTS ANALYSIS

(Awaiting Input)

APPENDIX I:

FINANCIAL PROVISION

(Awaiting Input)

APPENDIX J:

REHABILITATION PLAN

REHABILITATION PLAN

Prepared for:

Whale Head Minerals (Pty) Ltd

DMR Reference Number: NC30/5/1/3/2/10829MP

Report Prepared by:

PHS Consulting

May 2020

1. INTRODUCTION

Whale Head Minerals (Pty) Ltd has identified a mineral sand deposit with the aim of developing this resource to produce a saleable heavy mineral concentrate product from the wet concentrator plant (WCP), which would include garnet, ilmenite, monazite, zircon and rutile. It is estimated that approximately 622 700t of ore will be mined from the beach over a 5-year period, producing high grade heavy minerals concentrates.

The proposed mine site is situated approximately 2 km north of Jackals Pit, and 15 km north of Port Nolloth. The proposed 5 ha mining area is located in the surf zone adjacent to the Concession Cliffs.

2. PROJECT DESCRIPTION

The previously mined beach at Walviskop will now be mined for heavy minerals using an excavator fitted with a dredge pump (hydraulically driven submersible dredge pumps) onto the boom of an excavator feeding directly into a booster pump that will deliver the slurry into a main pipe spine along the beach. The mining rate has been estimated at rate of 260 tonnes per hour based on applying a non-conventional mining method to the project.

The mining operation proposed here will consist essentially of a land-based operation advancing from the beach into the surf zone by carrying a mining tool, the HY 300A hydraulic dredge pump, which will replace the bucket on an 80 t excavator. The pump is equipped with a high-pressure water jet ring system that delivers 100 m^3 of water at 6 – 7 bar onto the pump suction area. This water jet system will cause the liquefaction of the sand layer to the extent that the sand in the immediate vicinity of the pump will be kept in suspension through a combination of the turbulence caused by the water jets and motion of the sea water. Dredging will then focus on the suspended sediment comprising mainly sand at a rate of 900 m^3 slurry (up to 50 % solids). The mined sediment is pumped from the mining area on the beach, surf zone and breaker zone to the back beach via a 250 mm diameter pipe line to the WCP.

The mining operation will receive water from the process water dam as already mentioned, and it is foreseen that the water requirement would reduce as the amount of water in the feed increases with increasing depth of mining. Indications are that only the top 1.5 m of sand will be dry and the remainder of the resource 1.5 to 5 m deep will be waterlogged.

The process water dam will be fed from a single fixed sea water intake located close to the WCP. The sea water intake (SWI) will be in the form of a well field buried in this section of the beach. The SWI will supply water to the process water dam at a nominal rate of 360 m^3/h. The water table at the beach is approximately 1.5 m below the surface on average. This would also be a function of the distance from the shoreline and the tide.

The proposed mining activity is summarised below:

<u>Phase 1: Construction Phase – Plant Area and Infrastructure:</u>

- Road works
  - Existing access road to be upgraded (200mx7m)
- Plant Area (250m^2) - Above the HWM
  - The entire plant area will have a plastic lining to contain all possible sea water drainage and to avoid seawater infiltration into terrestrial areas. The plant site will also have a berm around it to contain spillage run off. No excavation will be required for the Plant Area.
  - Fuel storage area incl. 68 000l diesel tank to be located above ground and bunded.
  - Diesel Generators
  - Bag and bulk storage area.
  - Laboratory.
  - Ablution block c/w sewage and waste disposal facilities. A French drain will be installed.
  - Freshwater to be carted in for domestic use from Muisvlak.
  - Office block.
  - Tea room.
  - Wet Concentrator Plant (WCP).
  - Process Water Dam.
  - ROM Stockpile Gantry; feed bin and feed conveyor.
  - Workshop and Storage Shed
- Main pipe spine will be anchored at various points and will consists of 3 lines: a water line transporting water from the process water dam to the mining operation, a tailings line returning WCP tailings to the beach running adjacent to the water line, and a line transporting ROM slurry to the WCP from the mining operation.

- Two booster pumps will be installed on the pipeline.

Phase 2: Mining Operation:

- Beach material/slurry pumped at 260 tonnes per hour into main pipe spine along beach via excavator fitted with dredge pump.
- Sediment is pumped from mining area in surf zone and breaker zone to the beach via 250mm diameter pipe to the WCP.
- Mining operation will receive water via main pipe spine from a process water dam.
- The process water dam will be fed from a single fixed sea water intake located close to the WCP at 360m^3/h.

Phase 3: Processing:

- Wet Concentrator Plant (WCP) will receive sediment at a rate of approximately 260t/h. Some 5 - 10% of this will be retained as concentrate and the remaining 90 to 95% will be discarded as tailings.
- The plant will use sea water from the process water dam.

Phase 4: Waste Disposal:

- The non heavy mineral sand and oversize gravel fraction tailings from the WCP is considered waste and gets returned to the surf zone by means of gravity flow and gets re-distributed and deposited by the wave action on the beach.

Phase 5: Stockpile and Removal of heavy minerals:

- Volume of storage is approximately 35 000t with a frequency of removal of 4 x 34t loads daily.
- To be removed from site and taken to Minrite at Lutzville.
- No security required.

Phase 6: Rehabilitation/Closure:

- Rehabilitation as per specialist recommendations.
- Rehabilitation of access roads.
- Dismantling of processing plant.
- Demolition of steel buildings & structures.

- Demolition of reinforced concrete structures.
- Demolition of housing and facilities.
- Opencast rehabilitation including final voids and ramps.
- Rehabilitation of overburden and spoils.
- Processing waste deposits and evaporation ponds (salt).
- General surface rehab and grassing.
- Water management.

2-3 years of maintenance and aftercare.

3. REHABILITATION PLAN

A number of studies concerning rehabilitation have been carried out in the Alexander Bay Mining Complex (Grobler, 2008; Meyer & Carrick, 2010; Siteplan, 2014 (Mcdonald, 2017)). These projects have reflected variable success with the outcome of interventions to enhance restoration of disturbed and / or degraded sites. One of the most important principles identified, is that **maximum retention of natural vegetation is fundamental in any rehabilitation programme**.

Owing to the highly arid environment in which the mining project would take place, any disturbance (removal or trampling of vegetation) would take a long time to remedy. This is the principle reason for a precautionary approach whereby the habitat is disturbed as little as possible while still permitting the necessary activities for successful prospecting.

Apart from possible (probable) removal of vegetation at the mining site the other major anticipated negative impact would be unavoidable compaction of the soil. Taking this and other impacts into account, it is proposed that the following basic restorative steps should be taken at the mining site:

- Initiate restoration and rehabilitation as soon as mining is complete in an area. This should involve back-filling excavations using tailings and discards and restoring the beach profile to that resembling the pre-mining situation. No accumulations of tailings should be left above the high water mark.

- On cessation of operations, all mining equipment, artificial constructions or beach modifications created during mining must be removed from above and within the intertidal zone. All structures/ infrastructure should be removed.
- The site should be decontaminated of any oil or chemical spills.
- An appropriate seed-mix (determined from the composition of the surrounding undisturbed vegetation) should be obtained and broadcast over the disturbed terrestrial mining site. The seed should then be lightly raked into the soil.
- No watering of the site should take place; the seed should be allowed to germinate under the natural climatic regime to prevent die-off if germination occurs after an artificial regime caused by watering.
- The sites should be monitored over a two to three year period for success or otherwise of re-vegetation. If initially unsuccessful, a second attempt should be carried out.
- All restoration interventions should be carried out under the supervision of a qualified restoration ecologist or landscape practitioner.

Aspect/Impact	**Rehabilitation Measure**	**Monitoring Frequency and Responsibility**
Rehabilitation of access roads	Access road to be upgraded for distance of approximately 200m.	Once-off, after rehab is completed.
Plant area	Dismantling of processing plant. Demolition of steel buildings & structures; reinforced concrete structures; housing and facilities. Processing waste deposits and evaporation ponds (salt). General surface rehab and grassing. Water management.	Immediately after demolition/dismantling and 2-3 years of maintenance and aftercare.

Mine Area	Initiate restoration and rehabilitation as soon as mining is complete in an area. This should involve back-filling excavations using tailings and discards and restoring the beach profile to that resembling the pre-mining situation. No accumulations of tailings should be left above the high water mark. General surface rehab and grassing On cessation of operations, all mining equipment, artificial constructions or beach modifications created during mining must be removed from above and within the intertidal zone.	Immediately after rehabilitation and 2-3 years of maintenance and aftercare.

4. REHABILITATION COST SUMMARY

Exploitation of the heavy mineral sand resource at Walviskop, Port Nolloth, Northern Cape REHABILITATION COST				
Rehabilitation Plan Item	**Area**	**Rehabilitation Action**	**Unit Cost**	**Estimated Cost**
Note: The unit cost was determined using the DMR Master rates for financial provision (2005-2020) according to CPI %. Each rehabilitation action has a different cost. As per action: size x unit cost = action cost respectively.				
Rehabilitation of access roads	200m x 7m = 1400 m^2	Access road to be upgraded for distance of approximately 200m.	R 41.67 per m^2	R 58 338.00
Plant area	Area of plant: 250m^2	Dismantling of processing plant	R 16.72 per m^2	R 4 180.00
Plant area	Steel buildings and structures: 5m x 7.5m = 37.5 m^2	Demolition of steel buildings & structures	R 232.86 per m^2	R 8 732.25
Plant area	Concrete structures: 30m x 30m = 900 m^2	Demolition of reinforced concrete structures	R 343.17 per m^2	R 308 853.00
Plant area	350 m^2 housing	Demolition of housing and facilities	R 465.72 per m^2	R 163 002.00

Mine area	900 m^2 = 0.09 ha	Opencast rehabilitation including final voids and ramps	R 237 029.49 per ha	R 21 332.65
Mine area	1800 m^2 = 0.18 ha	Rehabilitation of overburden and spoils	R 162 758.61 per ha	R 29 296.55
Plant area	900 m^2 = 0.09 ha	Processing waste deposits and evaporation ponds (salt)	R 202 712.91 per ha	R 18 244.16
Plant and Mine area	2600 m^2 = 0.26 ha	General surface rehab and grassing	R 128 932.28 per ha	R 33 522.39
Plant area	2600 m^2 = 0.26 ha	Water management	R 49 023.68 per ha	R 12 746.16
Total				**R 641 827.16**
Maintenance and Aftercare				
Plant and Mine area	14 000 m^2 = 1.4 ha	2-3 years of maintenance and aftercare	R 17 158.29 per ha	R 24 021.61
Maintenance phase total				**R 24 021.61**
Total Rehabilitation provision				**R 665 848.77**

5. REFERENCES

Grobler, P.J. 2008. Environmental Management Report: Alexkor Mining Area (Vegetation). Unpublished report.

Meyer, A. & Carrick, P. 2010. Richtersveld Restoration Research Project Alexkor Mine 2008 –2009: Assessment of the Ecological Restoration Trials. Unpublished report – Nurture, restore, Innovate.